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REMEDIAL INVESTIGATION/FEASIBILITY STUDY
FOR
MONTGOMERY TOWNSHIP HOUSING DEVELOPMENT/ ROCKY HILL MUNICIPAL WELLFIELD SITE

VOLUME 1

REMEDIAL INVESTIGATION

Prepared For:

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF HAZARDOUS SITE MITIGATION
BUREAU OF SITE MANAGEMENT
TRENTON, NEW JERSEY 08625

Prepared By:

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APRIL 1988

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SECTION ONE
EXECUTIVE SUMMARY

In 1979 it was discovered that the Rocky Hill Municipal Wellfield (RHMW) and approximately one half of the private domestic wells in the Montgomery Township Housing Development (MTHD) were contaminated with trichloroethene (TCE) and other halogenated hydrocarbons. Initial findings prompted the United States Environmental Protection Agency to place the MTHD site and the RHMW site on the National Priority List (NPL) of hazardous waste sites in 1982. In 1985 Woodward-Clyde Consultants (WCC) was contracted by the New Jersey Department of Environmental Protection (NJDEP) to perform a Remedial Investigation/Feasibility Study (RI/FS) of both sites. The purpose of the RI/FS is to characterize the nature and extent of contamination, identify the source, if it is still present, and determine the appropriate response actions for the contamination.

WCC initiated a sampling program involving ground-water, surface-water, industrial septic tank, soil and air sampling. Results from this sampling program have revealed that a plume of contaminants roughly extends from Route 206 east to the Millstone River, north to Sycamore Lane and south to Route 518. Concentrations of TCE within the plume range from below contract detection limits (5 ug/l) to 650 ug/l in monitoring wells. A TCE concentration of 340 ug/l was detected in a domestic well on Robin Drive on one occasion. Based on calculated ground-water velocities it is impossible to discern whether the source or sources of contaminants is/are no longer present or whether the source/s is/are still releasing contaminants. During this study no TCE was detected in surface waters, septic tanks or soils. Ground-water flow patterns and contaminant distribution defined in this study have made it possible to reduce the likelihood that several of the parties believed to be potential sources of contamination are indeed sources. Environmental Cleanup Responsibility Act (ECRA) investigations at Princeton Gamma Tech (PGT) have recently found high levels of TCE in groundwater beneath the site. The levels decrease in all directions away from the property. This information combined with regional ground water data indicates a primary source of contamination in the area of PGT. The possibility remains that contribution from one or more secondary sources has occurred, however, the presence of TCE upgradient of these sources makes it difficult to evaluate their contribution.

Early results of this study have shown that residents of the MTHD continue to use their private wells are using water containing hazardous substances whose concentrations are in excess of those levels deemed to be safe by various health authorities. The feasibility of several alternatives for drinking water sources has [illegible] ed in an interim report (WCC, July 1987). Shortly after [illegible] NJDEP and the United States Environmental Protection [illegible] ed a Record of Decision (ROD). The ROD has resulted in [illegible] program through which all MTHD residents would be [illegible] Elizabethtown Water Company system.

SECTION TWO
INTRODUCTION

In 1979 it was discovered that water from the Rocky Hill Municipal Well, Rocky Hill, New Jersey, was contaminated with trichloroethene (TCE). The well was closed and Rocky Hill residents were provided an alternate water source. Subsequently, the well was attached to an airstripper and reopened. The discovery of contaminants in Rocky Hill prompted the sampling of 71 nearby private wells located in the Montgomery Township Housing Development (MTHD). Approximately half of these wells were found to be contaminated with TCE and other halogenated hydrocarbons. Within a year of the initial testing, Elizabethtown Water Company water lines were installed throughout the MTHD.

The United States Environmental Protection Agency (USEPA) ranked the Montgomery Township Housing Development site at number 413 on the National Priorities List with a score of 37.93; the Rocky Hill Municipal Wellfield Site (RHMW) was ranked at 414. New Jersey Department of Environmental Protection (NJDEP), operating under the Superfund Act of 1980, applied for and received grant assistance from the USEPA to investigate these sites.

Because of the proximity of the RHMW to the MTHD it was decided that the two sites be studied simultaneously under one contract. In 1985, Woodward-Clyde Consultants was awarded a contract to conduct a Remedial Investigation/ Feasibility Study (RI/FS) of the sites to determine potential sources of and solutions to the contamination problem. This report presents the final results of the RI/FS. An interim report based on initial findings was issued (WCC, July 1987) and resulted in the issuance of a Record of Decision (ROD) by the NJDEP and USEPA.

This report is issued in three volumes. Volume 1 contains background information on previous investigations (Section 3), a discussion of field methodologies employed in this study (Section 4), and a presentation and evaluation of the geophysical survey, geotechnical borings, and the ground water, surface water, septic tank, and air investigation (Section 5). Results of all of these facets of the investigation are integrated in Section 6 and summarized in Section 7. This work was performed in accordance with the Project Specific Request for Proposal for the Montgomery Township Housing Development/Rocky Hill Municipal Wellfield site pursuant to term contract for Feasibility Studies (X-206) issued on 14 February 1985.

Volume 2 contains the risk assessment and feasibility study for the MTHD/RHMW site. Volume 3 contains all appendices for Volumes 1 and 2.

SECTION THREE
SITE BACKGROUND INFORMATION

3.1 SITE LOCATION AND LAYOUT

3.1.1 Montgomery Township Housing Development

3.1.1.1 Location. Montgomery Township Housing Development (MTHD) is a 72-acre tract of land in Montgomery Township, Somerset County, New Jersey. The site is located at 74°35'0" west longitude and 40°24'0" north latitude.

The housing development is located within the area east of Route 206, north of Route 518, west of the Millstone River, and south of Beden Brook and Montgomery Road.

3.1.1.2 Site Layout. As shown on Plate 3-1, the adjacent properties to the north of Sycamore Avenue are wooded or agricultural lots. To the southwest are an office center (former site of two suspect sources) and two shopping centers. To the south is the Borough of Rocky Hill (population 960) which is primarily residential. A cemetery lies between the borough and the development, off of Montgomery Road. The homes on the end of Cleveland Circle are bordered to the east by the Millstone River, which parallels the Delaware and Raritan Canal.

The development itself consists of 71 approximately 1-acre home sites situated on Montgomery Road, Sycamore Lane, Robin Drive, Oxford Circle, and Cleveland Circle. The highest point, 140 ft above mean sea level (MSL), is at the end of Robin Drive and the lowest point, 60 ft above MSL, is at the end of Cleveland Circle.

This investigation was expanded to include some residences and areas beyond the boundaries of the MTHD. Ground-water investigations have included residences along Canal Road (east of the Delaware and Raritan Canal), Montgomery Road, and Routes 206 and 518; as well as some commercial establishments along Routes 206 and 518.

3.1.2 Rocky Hill Municipal Wellfield

3.1.2.1 Location. The Rocky Hill Municipal Wellfield is a 2-acre tract of land in the Borough of Rocky Hill, Somerset County, New Jersey (Figure 3-1). The site is located at 40°24'0" North latitude and 74°38'0" West longitude.

The wellfield is located to the east of New Jersey Route 206 and just south of NJ Route 518. Local tax maps identify the property as Block 5, Lot 1 (Plate 3-1).

3.1.2.2 Site Layout. The wellfield is bounded on the north by residences fronting on Route 518 (also known as Washington Street). Immediately west of the site is a commercial center. The wellfield is bounded on the east by townhouses and undeveloped fields. An open field (formerly an aircraft landing strip) lies southeast of the wellfield, and Princeton Airport is approximately 2,000 ft southwest of the site.

Most of the property in the general vicinity of Rocky Hill is moderately developed residentially or commercially. The only undeveloped area within one-half mile of the site is the open field southeast of the site.

Two structures containing wells are located on the wellfield, one housing the functioning well and one that has been abandoned. In addition, two air stripping units have been constructed and are operational, having a combined capacity of 250 gallons per minute. Potable water is stored in a 100,000 gallon water tower located adjacent to the well house building. The functioning well (#2) extends to a depth of 278 ft. Results of chemical analyses performed on pre-treatment samples from the Rocky Hill Well are summarized in Appendix B. The Rocky Hill Well has contained up to 214 ppb of TCE.

3.2 SITE HISTORY

3.2.1 Montgomery Township Housing Development

Tax records and accompanying maps indicate that the housing development site was owned by Harry A. Hey (50.59 acres) and D.B. Hamman (33 acres) until 1961. The land was used for farming and there is no knowledge of any underground tanks or landfill areas on the property at that time. Tri State Development Corp., owned by Mr. Charles Egner, purchased the land in 1961. Construction on the homes began in 1961 and the area was divided into 71 lots with private wells and septic tanks.

In 1978, a study by Rutgers University on the Rocky Hill Borough well revealed trichloroethene (TCE) contamination levels of about 25 ug/l (ppb). Continued testing of this water supply from 1978 to 1983 indicated that the TCE concentration ranged from about 50 to 200 ug/l in this well. Concern over the ground water contamination in Rocky Hill spurred the initial sampling of commercial and domestic wells in Montgomery Township from December, 1979 to January, 1980 (Searfoss, 7 July 1983) and continued environmental investigations through the present.

In March, 1981 Elizabethtown Water Company water lines were installed in Montgomery Township housing development, and residents were advised not to use well water. Twenty homes initially elected to hookup to the municipal supply. At the present time, 38 residences have hooked up. Residences not connected to the municipal water supply are listed in Table 5-9. In January, 1986, NJDEP Division of Water Resources placed a restriction on future well drilling for water supply wells in the area (Evenson, 1986). In September 1987, a Record of Decision (ROD) was issued by the NJDEP and the USEPA. This ROD implements the permanent hookup of all MTHD residences to the Elizabethtown Water Company system.

3.2.2 Rocky Hill Municipal Wellfield

Wells Number 1 and 2 were completed in 1936 (Greenfield, 1937). These two wells provided a source of potable water to the Borough of Rocky Hill. Well Number 1, located on the southern portion of the wellfield, was abandoned and sealed between 1976 and 1978. Because of elevated levels of TCE in the water of Well Number 2, this well was also shut down on 14 November 1979 (Trenton Times, 1979). Levels of TCE in the well water eventually declined, and the well was subsequently approved in July 1981 by NJDEP as a municipal water supply (The Princeton Packet, 1981). Levels of TCE, however, increased, and the well was shut down for a second time in January 1982 (Geoghan, 1982). During the shutdown of Well Number 2, Rocky Hill Borough obtained potable water from the Elizabethtown Water Company. After the installation of two air stripping units for Well Number 2, the well was reopened as a potable source of water on 27 July 1983 (Merk, 1983).

3.3 ENVIRONMENTAL SETTING

3.3.1 Geology

3.3.1.1 Unconsolidated Deposits. The MTHD site lies in the Piedmont Physiographic Province and is underlain by bedrock of the Brunswick Formation covered with a relatively thin (up to about 30 ft thick) veneer of unconsolidated sediments. The unconsolidated sediments predominantly consist of residual soil formed by weathering of the underlying bedrock. The residual soil generally is composed of clay, silt, and fragments of unweathered shale. Pre-Wisconsin, possibly Jerseyan, glacial deposits, which include glacial till or gravels, have also been noted in the area (Neuman, 1980) but these are limited in extent.

3.3.1.2 Bedrock. The Brunswick Formation is the youngest, thickest, and most extensive unit of the Newark Group of late Triassic Age. In the area of interest, the Brunswick Formation consists of varying thicknesses of red shale, mudstone, siltstone, sandstone, and argillite. The Brunswick Formation is usually weathered to a depth of several feet where it consists of clay with rock fragments.

South of Rocky Hill, the bedrock consists of diabase. The contact between the Brunswick Formation and the diabase trends northeast-southwest, consistent with the regional structural trend. At the contact with the diabase intrusion, the shale is contact metamorphosed to hornfels.

The strike of the Brunswick Formation bedding is generally northeast; dips are generally in the range of 12° to 13° NW. Several topographic features in the vicinity of the project have a nearly east-west trend suggesting fracturing/jointing in this direction. Locally, the strike of these beds differs markedly from the regional northeasterly trend.

The following fracture systems resulting from jointing have been reported:

- vertical or near vertical fractures that generally parallel the strike of the bedding;
- vertical or near vertical fractures that are generally perpendicular to the strike;
- occasional steeply dipping joints that cross-cut the aforementioned two systems; and
- bedding-plane joints which are common in surface exposures.

Major and minor faults also occur in the rocks of the Newark Group, with most of the faults trending northeastward.

3.3.2 Hydrology

3.3.2.1 Ground Water. Regionally, the Brunswick Formation is the principal aquifer. Ground water exists in a number of water-bearing zones which are generally under unconfined to semi-confined conditions. Semi-artesian and artesian conditions can occur locally where marked differences exist in the vertical permeability of the formation. Artesian conditions also exist in some lowland areas, where the Brunswick Formation is overlain by relatively impermeable clayey soils.

The intersecting fractures that have resulted from the jointing provide the principal means of storage and movement of ground water in the Brunswick Formation. This is supported by observations made in several long tunnels through the bedrock, where frequent streams of water were reportedly observed to follow vertical fissures, whereas the bedding planes were nearly dry.

Data collected during pumping tests of wells throughout the outcrop area indicate that the aquifer in the Brunswick Shale possesses anisotropic hydraulic properties related to the structure of the formation (Vecchioli, 1967). This is based on the field observation that wells aligned parallel to the strike of the Brunswick Shale exhibited greater drawdown than other wells during pumping tests. For example, measurable drawdown was reported in monitoring wells located a mile away from a pumping well along the strike of the Brunswick Formation.

Vecchioli, et al. (1969) indicate that the degree of anisotropy in hydraulic properties of the Brunswick Shale varies from one area to another. In some areas, it is considerably less anisotropic than in others, and locally may even be nearly isotropic. Nonetheless, according to these authors, the drawdown during pumping is found to be always greatest along strike.

The practical implication of the directional hydraulic behavior of the Brunswick aquifer is that the ground water is able to flow more freely in the direction of strike, and therefore the facility for contaminant migration would be greatest along strike. Such a condition was observed in Newark, New Jersey, where elongated tongues of salt water have encroached in directions parallel to strike (Herpers and Barksdale, 1951).

3.3.2.2 Water-Supply Wells. The ground water in the Brunswick Shale is extensively pumped for domestic and industrial use. More than 90 wells have been recorded to exist within a 1-mile radius from the center of the area of study (Table 3-1). (This tabulation does not include non-permitted wells.) Locations of wells are illustrated in Figure 3-2. The sum of the reported yields of the permitted water-supply wells is on the order of 2,000 gpm.

3.4 PREVIOUS INVESTIGATIONS

3.4.1 Previous Remedial Response Activities

Response activities for the Montgomery Township Housing Development Site and the Rocky Hill Municipal Well (RHMW) have been undertaken by NJDEP and others since 1979. A summary of these activities is presented in Appendix A.

The previous response activities included sampling and testing of:

- water from private wells;
- water from industrial water-supply wells;
- soil at potential responsible parties' sites and background soils;
- water from surface-water bodies;
- septic tanks;
- industrial effluent;
- industrial storage drums;
- industrial tanks;
- Elizabethtown Water Company water; and
- stream sediments.

Physical remedial action included:

- Installation of Elizabethtown water lines in March, 1981;
- Shutting down of Rocky Hill Municipal Well No. 2 in November, 1979;
- Repair of sewers at Princeton Gamma Tech;
- Installation of air-stripping unit at RHMW No. 2 and reopening of RHMW; and
- Installation of home water-purifying devices by residents of Montgomery Township Housing Development who elected to do so.

A chronology of testing for TCE and other contaminants in the MTHD wells is presented in Appendix B. The results are discussed in conjunction with recent data in Section 5.3.

3.4.2 Potential Sources of Contamination

Several industrial and commercial establishments within the site area are believed to be potential sources of contamination (Potentially Responsible Parties, PRPs). Some of the PRPs have on-site wells which have been sampled and for which analytical data was available. Several hazardous substance losses, potentially having environmental impact, occurred between 1970 and 1979. In addition to the establishments listed below, domestic and/or commercial septic systems have been cited as a potential contributory point or nonpoint source of contamination. (See Section 3.4.3.4.)

Because there is a possibility that the potential source or sources of ground water contamination might be the same for both the MTHD and the RHMW, these sources are listed together. A brief description of the PRPs is presented below.

- Texaco Station - This service station is located at the northwest corner of Routes 206 and 518. It has a septic tank for sanitary waste, a 550 gallon underground tank for waste oil, and a small solvent reclamation system.

- Mobil Station (also known as Collin's Garage) - This service station was located at the northeast corner of Routes 206 and 518. It had a septic tank for sanitary wastes and a 275 gallon underground waste oil tank. No solvents were used (Wishart, 14 December 1979). Thul's Auto Body was adjacent to the station. Thul's was an auto parts store and there may have been some machining and use of solvents or degreasers. This property has changed ownership and is currently the site of a Wawa's convenience store.

- William Penn - This service station is located at the southeast corner of Routes 206 and 518. It has a septic tank for sanitary waste, a 550 gallon inground waste oil storage tank, and a small reclamation system for solvents (Wishart, 14 December 1979).

- Princeton Volkswagen - This establishment is located on the west side of Route 206, 300 yards south of Route 518 and 330 yards west of the Rocky Hill municipal well. The facility uses the municipal sewer system, a 1,000 gallon underground waste oil tank, and a small solvent recovery system. Acetone (600 ppb) and methylene chloride (37 ppb) were detected in soil samples from this site in 1987.

- Princeton Airport - The airport, owned by Princeton Aero Corp., is located one-half mile southwest of the Route 206 and 518 intersection. The facility has a 250 gallon above ground waste oil tank, an underground airplane fuel storage tank, and solvent reclamation system (Wishart, 14 December 1979). An oil-water separator has, at times, not been operating properly, and has spilled its contents onto surrounding soil. A staging area for waste oil drums had also contaminated immediate soils. The underground gasoline storage tank has been removed. Sampling has been conducted at several well and soil sites. Trenches have been dug around the gasoline tank for water and sediment analysis. Airport personnel installed nine monitoring wells on site. An administrative order directed at this facility is pending and will address their underground tank and oil separator spills.

- 1377 Route 206 - This facility is an office building and has several tenants. It is located on the east side of Route 206 north of the Route 518 intersection. Formerly, the building housed Princeton Chemical Research (PCR). While it operated as PCR, the facility mixed milled and extrded rubber compounds into golf balls, and manufactured pyromellitic dianhydrides, BTA (Benzophenone Tetracarboxylic Acid), and other specialty chemical products. Over 400 ppb of TCE has been detected in the well at this facility. Aside from ground-water contamination problems detected in the on-site wells, there is also an area of PCB-contaminated soil adjacent to the back door of the plant. In addition, Public Service electric transformers, potential sources of PCBs, are adjacent to the site. There was a tank farm to the rear of the site and an area reportedly used for spray waste irrigation. The plant has a history of environmental problems including a chemical spill into Beden Brook (1972) and a resultant fish kill (Jacangelo, 14 January 1974). The septic tank, two abandoned wells, and four levels of soil have been sampled for volatile halogenated compounds and PCBs. The state installed a background monitoring well at the Village Shopper (across Route 206 from 1377 Route 206). As a result of past disposal practices, the NJDEP Division of Water Resources is engaging in compliance development under an administrative order issued in Princeton Chemical Research in 1986. The results of previous sampling are summarized in Appendix B.

- Polycell - This facility, owned by Rocky Hill Realty, was located on the east side of Route 206 north of Route 518 and just south of 1377

Route 206. The facility was in the plastic extrusion business but was destroyed by fire about eight years ago. The four conduit lines that were located on site contained p-dichlorobenzene and hexachlorobutadiene. The abandoned well is still being used for monitoring purposes. State and township offices have very sketchy information on this operation (Searfoss, 7 July 1983).

- Compo Industries (also known as Ameliotex and Hercules, Inc.) - This facility was located on Crescent Avenue south of Route 518 in Rocky Hill Borough. The property is owned by Rocky Hill Partners. The operation has been discontinued as of its 1 July 1983 permit expiration date (Searfoss, 7 July 1983). The facility was engaged in the production of urethane resins and reclamation of spent dimethyl formide (DMF). The facility was connected to the municipal sewer system and directly discharged non-contact cooling water to the Millstone River. The two wells on the site are production wells. One NJDEP monitoring well is on the adjacent property. Although TCE has been found in the deeper Compo well (310 ft), it was not one of the raw materials reported to have been used by Compo or the previous two tenants, Ameliotex or Hercules, Inc. (Wishart, 14 December 1979). Effluent sample tests from Compo operations at the Millstone River discharge revealed high levels of several volatile materials including toluene, methyl ethyl ketone, and xylene (Burns, 6 April 1981, 13 April 1981). There were about 500 drums of chemical waste and several abandoned tank trailers on the site. Some of the drums were noted to be leaking. The drums have been removed to an off-site location.

- Princeton Gamma Tech - This facility is located on the north side of Route 518 just east of the Route 206 intersection. This facility manufacturers radar detection equipment and lab analysis equipment. The building is serviced by a large septic system used for the disposal of sanitary and lab sink waste (Wishart 14 December 1979). The lab had reportedly used TCE (1-2 gallons per month) in the past. The well, septic tank, and several soil horizons have been sampled and tested for chlorinated hydrocarbons. Results of these sampling events are summarized in Appendix B. The septic tank was found to have TCE concentrations of 8900 ppb (Miller, 2 April 1980). NJDEP ordered the tank to be emptied and cleaned and use was discontinued until satisfactory sample results were obtained. This site currently is undergoing investigation under the Environmental Cleanup Responsibility Act (ECRA).

- Ingersoll Rand Corp. - This facility is located on Montgomery Road, northeast of the development, and adjacent to Millstone River. The facility is currently unoccupied. Testing and research of drilling equipment was done at this plant. The plant had its own sewage treatment facility for domestic waste. Some TCE was used as a degreaser for the machinery. There is a private potable water well on the property (Wishart 14 July 1979). Due to the pending sale of this property Ingersoll Rand is currently engaged in ECRA compliance activities.

- Montgomery Township Shopping Center - This shopping center is owned by Rocky Hill Realty and is located approximately 600 ft north of Route 518 on Route 206 East. Elevated concentrations of trichloroethane, 1,1 - dichlorethane and methylene chloride have been recorded in the septic system at the shopping center (NJDOH, 1980).

- Town and Country Animal Hospital - This facility is located on the south side of Route 518, approximately 400 ft each of the intersection of Routes 206 and 518. There is no record of chemical use or disposal at the site. Previous sampling at this facility has been limited to ground water sampling. Ground water samples collected in 1982 and 1983 showed no contamination at this facility.

- o Village Shopper - This facility is a shopping center comprised of several establishments including a convenience store, restaurant, tanning facility and retain stores. Three septic tanks are located on the site. Previous sampling at this facility has been limited to ground water. Samples collected in 1982 and 1983 contained extremely low level (1-6 ppb) of 1,1-dichloroethane, toluene, tetrachloroethene and methylene chloride.

3.4.3 Previous Analytic Results

3.4.3.1 Soil Quality. Only limited historical data are available describing soil contamination at industrial and commercial sites that are potential sources. Results of soil sampling at selected industrial and commercial facilities indicate that:

- o 1377 Route 206 (PCR) has soil contaminated with PCBs, chloroform, acetone, phthalates, penols and benzoic acid.
- o Princeton Airport has areas where soils are contaminated with volatile organic compounds which are typical fuel oil components.
- o Princeton Gamma Tech had no contamination detected in soil samples collected down to a depth of 21 ft prior to this study.

3.4.3.2 Ground-Water Quality. Since the discovery of TCE contamination in the Rocky Hill Municipal Well in 1979, the ground-water quality in the Montgomery Township area has been extensively studied by NJDEP. Several rounds of sampling and analytical testing were conducted from municipal, private and commercial wells (Appendix A). The analytical data documented a serious ground-water pollution problem in Montgomery Township. TCE was found to be the dominant contaminant, but other chlorinated solvents were also detected.

Analytical results from previous studies are compiled in Appendix B. Locations of domestic wells samples from this and previous studies are shown in Figure B-1 of Appendix B.

Figure 3-3 is a summary of previous investigations of contamination in MTHD wells, excluding the 1986-1987 WCC data discussed in Section 5. Data shown are mean averages of TCE concentrations found in domestic wells between 1979 and 1984. Residences at the ends of Robin Drive, Oxford Circle and Cleveland Circle were found to have the highest TCE concentrations, whereas lower TCE concentrations were found in wells along Sycamore Lane. TCE was not detected in any domestic wells on the northern part of Montgomery Road, along its east-west stretch. In general, TCE concentrations in individual wells did not appear to vary significantly with time.

3.4.3.3 Surface Water/Effluent Discharge. Historical analytical data for surface water and industrial effluent are limited to a small number of samples. Available data are summarized in Appendix B. Water containing low levels of contaminants was being discharged to Beden Brook from 1377 Route 206 in 1973 and 1974. In 1979 and 1981 water containing high levels of xylenes, ketones and other organic compounds was being discharged to the Millstone River by Compo Industries.

3.4.3.4 Septic Tanks. TCE is a common component in septic system cleaners and it is possible that residential septic tanks are potential contributors to ground-water contamination.

Sampling of septic tanks at the industrial and commercial establishments (summarized in Appendix B) indicated:

- Montgomery Shopping Center - chlorinated volatile and semi-voltile organic compounds were detected in concentrations up to 15,000 ppb (Trichloroethane; 2/11/80).

- o Princeton Gamma Tech - TCE was detected at 8,900 ppb in 1979. High levels of toluene, chloroform and benzene were also detected at that time.

- o Compo Industries - TCE was detected at 62 ppb in 1980. Low levels of several other chlorinated volatile organic compounds were detected at that time.

- o 1377 Route 206 - TCE was detected at 95 ppb in 1980. No other organic compounds were detected at that time.

- o Polycell - TCE was detected at 31.4 ppb in 1980. Four other organic compounds were detected at lesser concentrations at that time.

3.4.3.5 <u>**Air Quality**</u>. No on-site air quality data is available for MTHD or RHMW. No information was found to indicate that air quality monitoring was performed to address potential TCE problems in either Montgomery Township or Rocky Hill Borough.

TABLE 3-1

INVENTORY OF EXISTING WATER WELLS
WITHIN THE MONTGOMERY TOWNSHIP/ROCKY HILL
STUDY CORRIDOR

Ref. No.	New Jersey Coordinate System Location No.	Reported Address	Original Owner	Date Drilled	Total Depth (ft)	Reported Yield (gpm)	Well Diameter (in)	Length of Casing Installed (ft)	Depth of Interval Screened (ft)	Length of Open, Uncased Section (ft)	Casing and Screen Material	Depth to Static Water on Date Drilled (ft)	Depth to Pumping Water Level (ft)	Use	Aquifer	Analyses of Well Water
1	20-2-445	Opossum Road, Montgomery Twp	Anthony Pinelli	20 Jul 1968	152	9	6	51	Unscreened	101	Steel	22	100	Domestic	Red Shale	Not Sampled
2	20-2-445	Opossum Road, Montgomery Twp	Joseph Tufano	6 May 1964	153	15	6	34	Unscreened	119	Steel	30	70	Domestic	Red Shale	Not Sampled
3	20-2-445	Opossum Road, Montgomery Twp	Richard Pasey	2 Jun 1963	110	6	6	35	Unscreened	75	Steel	30	90	Domestic	Shale	Not Sampled
4	20-2-446	Montgomery Twp	Richard Bell	9 Mar 1956	130	15	6	32	Unscreened	98	Steel	22	70	Domestic	Sandstone	Not Sampled
5	20-2-452	Mt. Lucas Road, Princeton Twp	Arthur Bell	13 Aug 1952	94	4	6	23	Unscreened	71	Steel	16	70	Domestic	Sandstone	Not Sampled
6	20-2-452	Montgomery Twp	Lester Schlapfer	8 Aug 1953	195	20	6	33	Unscreened	162	Steel	45	95	Domestic	Shale	Not Sampled
7	20-2-456	Montgomery Twp	Louis Balestrieri	24 Nov 1962	148	9	6	31	Unscreened	117	Steel	20	100	Domestic	Red Shale	Not Sampled
8	20-2-458	Montgomery Twp	Henry Young	2 Nov 1953	102	6	6	34	Unscreened	68	Steel	15	80	Domestic	Red Shale	Not Sampled
9	20-2-467	Montgomery Twp	Henry Young	14 Nov 1951	88	10	6	22	Unscreened	66	Steel	48	48	Domestic	Shale	NA
10	20-2-468	Mongomery Road, Montgomery Twp	Ingersoll-Rand Research Center	16 Aug 1966	250	40	6	40	Unscreened	210	Steel	25	200	Laboratory	Bluish-Grey Shale	Not Sampled
11	20-2-468	Montgomery Road, Montgomery Twp	Ingersoll-Rand Research Center	3 Aug 1966	250	30	6	NA	Unscreened	NA	Steel	40	200	Laboratory	Bluish-Grey Shale	Not Sampled
12	20-2-468	Montgomery Road, Montgomery Twp	Ingersoll Rand Research Center	30 May 1985	506	125	10	40	Unscreened	466	Steel	11	100	Laboratory	Red Shale	NA
13	20-2-471	Montgomery Twp	William T. Lord	23 May 1955	204	NA	6	24	Unscreened	180	Steel	32	90	Domestic	Red Shale	Not Sampled
14	20-2-471	Montgomery Twp	Albert Nice	24 Feb 1954	113	10	6	21	Unscreened	92	Steel	39	39	Domestic	Shale	Not Sampled
15	20-2-472	Opossum Road	Guy Divisio	9 Feb 1973	240	8	6	52	Unscreened	188	Steel	5	150	Domestic	Red Shale	Not Sampled
16	20-2-472	Opossum Road	Michael Temosi	3 Aug 1963	160	3	6	35	Unscreened	125	Steel	30	130	Domestic	Red Shale	Not Sampled
17	20-2-474	Rt. 518, Montgomery Twp	Brain Bio-Center	19 Jun 1980	150	70	6	25	Unscreened	80	Steel	50	50	NA	NA	NA
18	20-2-475	Rocky Hill Road, Montgomery Twp	R.L. Hunt	16 May 1956	90	15	6	42	Unscreened	48	Steel	26	55	Domestic	Shale	Not Sampled
19	20-2-475	Rt. 518, Montgomery Twp	Clifford Dunn	16 Jun 1953	130	8	6	33	Unscreened	97	Steel	32	70	Domestic	Red Shale	Not Sampled
20	20-2-476	Montgomery Twp	Donald Perkins	24 Aug 1956	127	8	6	30	Unscreened	97	Steel	35	70	Domestic	Red Shale	Not Sampled
21	20-2-479	Mountain View Rd, Montgomery Twp	John Bacchino	2 Dec 1976	240	15	6	50	Unscreened	190	Steel	50	150	Domestic	Bluish-Grey Shale	Not Sampled
22	20-2-482	Rt. 206, Montgomery Twp	NJDEP, Water Resources	5 Feb 1982	75	10	4	20	Unscreened	55	Steel	5	NA	Monitoring	NA	NA
23	20-2-483	Montgomery Twp	Charles Egner	10 Dec 1962	142	9	6	46	Unscreened	96	Steel	30	70	Domestic	Red Shale	Not Sampled
24	20-2-483	NA	Tri-State Development Co.	10 Jun 1965	158	10	6	43	Unscreened	115	Steel	67	80	Domestic	Red Shale	Not Sampled
25	20-2-483	Montgomery Twp	Mundy-Nestler, Inc.	16 Dec 1963	122	9	6	47	Unscreened	75	Steel	45	70	Domestic	Shale	Not Sampled
26	20-2-484	Rt. 518, Montgomery Twp	Alexander Ried	4 Jan 1956	129	8	6	33	Unscreened	96	Steel	35	70	Domestic	Red Shale	Not Sampled

TABLE 3-1, CONTINUED

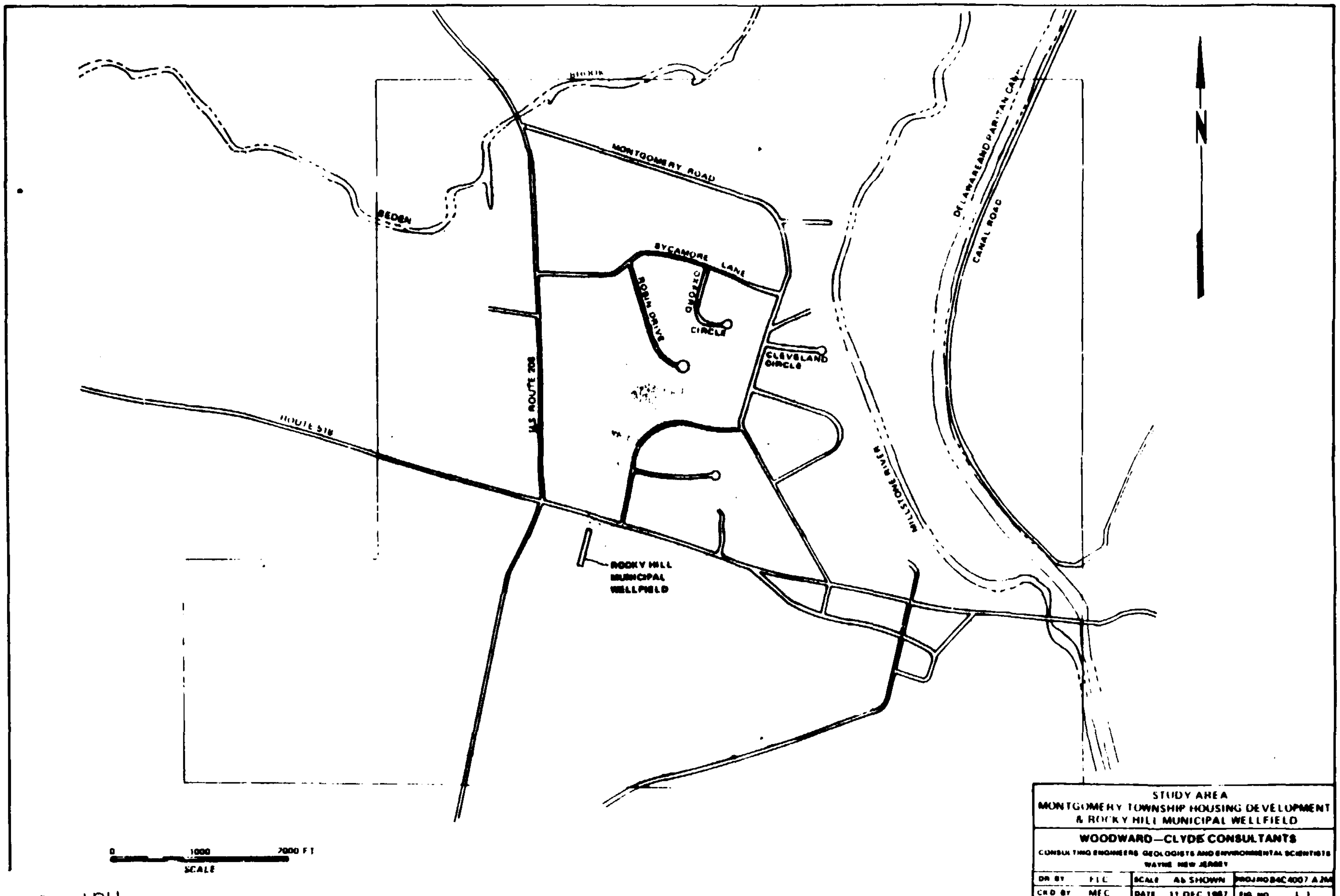
Ref. No.	New Jersey Coordinate System Location No.	Reported Address	Original Owner	Date Drilled	Total Depth (ft)	Reported Yield (gpm)	Well Diameter (in)	Length of Casing Installed (ft)	Depth of Interval Screened (ft)	Length of Open, Uncased Section (ft)	Casing and Screen Material	Depth to Static Water on Date Drilled (ft)	Depth to Pumping Water Level (ft)	Use	Aquifer	Analyses of Well Water
27	28-2-484	Montgomery Twp	Charles Egner	4 Dec 1961	100	10	6	36	Unscreened	64	Steel	20	80	Domestic	Red Shale	Not Sampled
28	28-2-485	Montgomery Twp	Rocky-Hill Realty	14 Sept 1964	150	40	6	33	Unscreened	117	Steel	25	120	Domestic	Red Shale	Not Sampled
29	28-2-485	Montgomery Twp	Edmund Schuster	31 Aug 1961	122	10	6	45	Unscreened	77	Steel	30	52	Domestic	Shale	Not Sampled
30	28-2-486	Montgomery Twp	Rocky-Hill Realty	31 Oct 1963	150	40	6	45	Unscreened	105	Steel	30	80	Domestic	Red Shale	Not Sampled
31	28-2-486	Montgomery Twp	Bei Baltzer Enterprises	Jun 1983	255	70	6	50	Unscreened	205	Steel	20	NA	Loop System Heat Pump	Shale	Not Sampled
32	28-2-486	Montgomery Twp	Bei Baltzer Enterprises	Jun 1983	255	70	6	50	Unscreened	205	Steel	20	NA	Loop System Heat Pump	Shale	Not Sampled
33	28-2-486	Montgomery Twp	Bei Baltzer Enterprises	Jun 1983	398	100	6	50	Unscreened	348	Steel	25	NA	Loop System Heat Pump	Shale	Not Sampled
34	28-2-486	Montgomery Twp	Mundy-Nestler, Inc.	5 Feb 1964	86	7	6	50	Unscreened	36	Steel	37	55	Domestic	Sandstone	Not Sampled
35	28-2-486	Montgomery Twp	Mundy-Nestler, Inc.	27 Sept 1963	152	7	6	50	Unscreened	102	Steel	45	75	Domestic	Shale	Not Sampled
36	28-2-486	Montgomery Twp	George Sands	6 Nov 1961	130	40	6	32	Unscreened	98	Steel	20	55	Domestic	Red Shale	Not Sampled
37	28-2-486	Montgomery Twp	Charles Egner	14 May 1962	249	6	6	34	Unscreened	215	Steel	24	80	Domestic	Red Shale	Not Sampled
38	28-2-487	Montgomery Twp	Walter Stenski	25 May 1956	121	10	6	46	Unscreened	75	Steel	32	41	Domestic	Shale	Not Sampled
39	28-2-487	Montgomery Twp	All-Star Builders	22 Jul 1963	137	15	6	40	Unscreened	97	Steel	50	90	Domestic	Shale	Not Sampled
40	28-2-487	Rt. 518, Montgomery Twp	Charles Perpetua	30 Jun 1963	120	20	6	51	Unscreened	69	Steel	50	80	Domestic	Shale	Not Sampled
41	28-2-487	Montgomery Twp	James T. Collins	30 Oct 1953	100	6	6	34	Unscreened	66	Steel	25	60	Domestic	Red Shale	Not Sampled
42	28-2-489	NA	Longridge Builders, Inc.	6 May 1963	278	62	10	42	Unscreened	236	Steel	28	160	NA	Red Shale	Not Sampled
43	28-2-489	Montgomery Twp	George Sands	16 Nov 1961	130	50	6	30	Unscreened	100	Steel	35	100	Domestic	Red Shale	Not Sampled
44	28-2-491	Montgomery Twp	Charles Egner	30 Nov 1962	138	10	6	34	Unscreened	104	Steel	30	75	Domestic	Red Shale	Not Sampled
45	28-2-491	Montgomery Twp	Charles Egner	20 Nov 1962	150	10	6	46	Unscreened	104	Steel	32	70	Domestic	Red Shale	Not Sampled
46	28-2-491	Montgomery Twp	Henry Young	20 Sept 1954	189	10	6	22	Unscreened	167	Steel	25	140	Domestic	Red Shale	Not Sampled
47	28-2-494	Montgomery Twp	Charles Egner	28 Apr 1964	156	7	6	50	Unscreened	106	Steel	64	80	Domestic	Red Shale	Not Sampled
48	28-2-494	Montgomery Twp	Charles Egner	25 Apr 1963	122	10	6	50	Unscreened	72	Steel	42	50	Domestic	Red Shale	Not Sampled
49	28-2-494	Montgomery Twp	Charles Egner	30 Jan 1963	140	10	6	50	Unscreened	90	Steel	25	70	Domestic	Red Shale	Not Sampled
50	28-2-494	Montgomery Twp	Charles Egner	13 Nov 1962	179	10	6	47	Unscreened	132	Steel	20	60	Domestic	Red Shale	Not Sampled
51	28-2-494	Montgomery Twp	Mundy-Nestler, Inc.	22 May 1963	113	7	6	50	Unscreened	63	Steel	58	75	Domestic	Shale	Not Sampled
52	28-2-494	Montgomery Twp	Charles Egner	21 Sept 1962	149	15	6	34	Unscreened	115	Steel	22	50	Domestic	Red Shale	Not Sampled

TABLE 3-1, CONTINUED

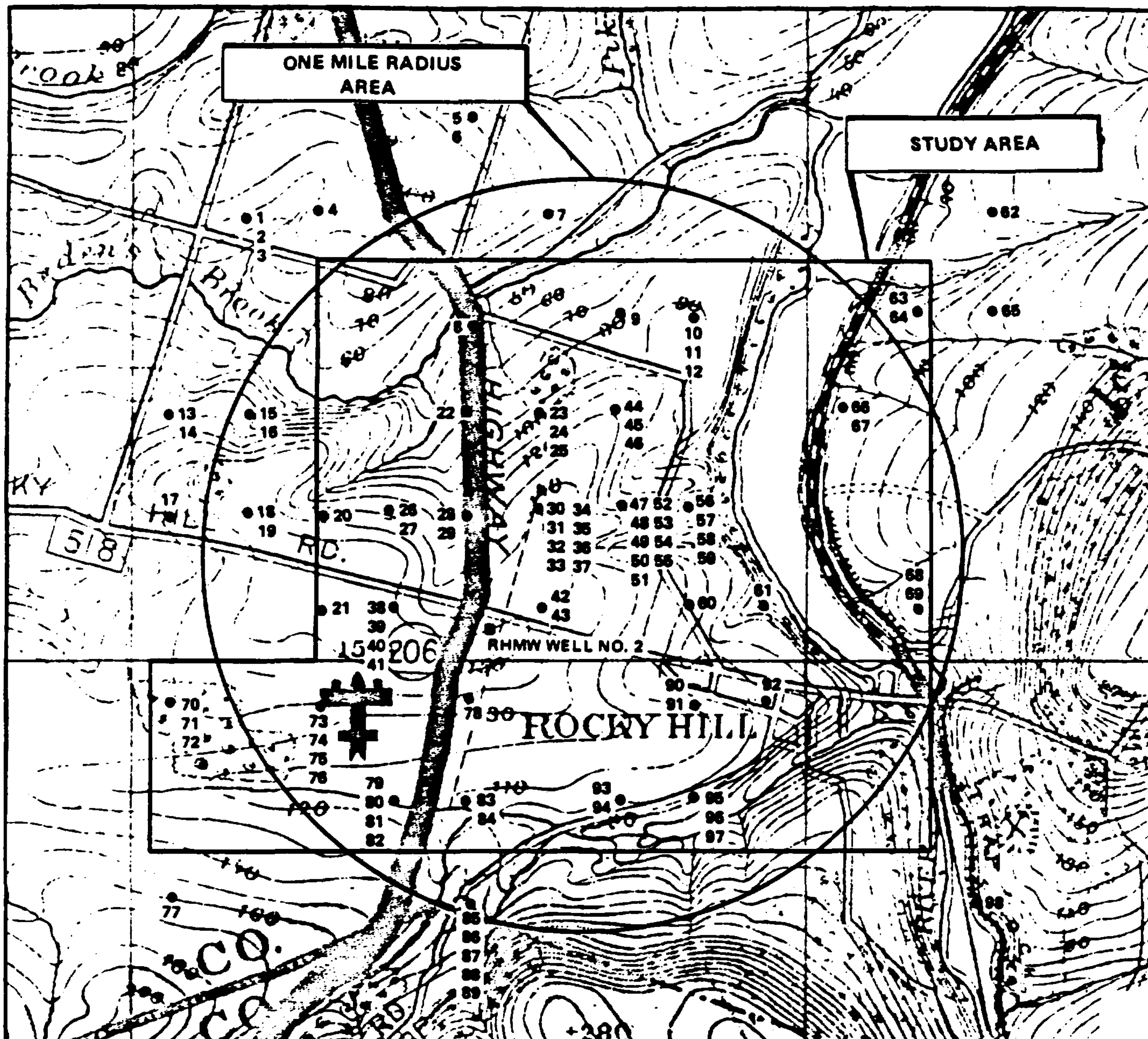
Ref. No.	New Jersey Coordinate System Location No.	Reported Address	Original Owner	Date Drilled	Total Depth (ft)	Reported Yield (gpm)	Well Diameter (in)	Length of Casing Installed (ft)	Depth of Interval Screened (ft)	Length of Open, Uncased Section (ft)	Casing and Screen Material	Depth to Static Water on Date Drilled (ft)	Depth to Pumping Water Level (ft)	Use	Aquifer	Analyses of Well Water
53	28-2-494	Montgomery Twp	Mundy-Nestler, Inc.	21 May 1963	115	7	6	50	Unscreened	65	Steel	42	75	Domestic	Shale	Not Sampled
54	28-2-494	Montgomery Twp	Mundy-Nestler, Inc.	23 May 1963	147	5	6	50	Unscreened	97	Steel	48	75	Domestic	Shale	Not Sampled
55	28-2-494	Montgomery Twp	Charles Egner	12 Apr 1962	235	8	6	24	Unscreened	211	Steel	32	160	Domestic	Red Shale	Not Sampled
56	28-2-495	Cleveland Circle, Montgomery Twp	Fisher-Ancona Builders, Inc.	21 Jun 1966	123	20	6	52	Unscreened	71	Steel	30	100	Domestic	Red Shale	Not Sampled
57	28-2-495	Cleveland Circle, Montgomery Twp	Fisher-Ancona Builders, Inc.	30 Nov 1967	193	50	6	50	Unscreened	143	Steel	20	150	Domestic	Shale	Not Sampled
58	28-2-495	Montgomery Twp	Charles Egner	9 May 1962	100	7	6	23	Unscreened	77	Steel	16	70	Domestic	Red Shale	Not Sampled
59	28-2-495	Montgomery Twp	Charles Egner	28 Aug 1961	166	3	6	22	Unscreened	144	Steel	30	140	Domestic	Red Shale	Not Sampled
60	28-2-498	Montgomery Twp	Rock-Hill Realty Co.	14 Mar 1962	500	205	10	40	Unscreened	460	Steel	0	118	Test Well	Red Shale	Not Sampled
61	28-2-499	Montgomery Twp	Charles Egner	26 Sept 1961	150	4	6	23	Unscreened	127	Steel	25	90	Domestic	Red Shale	Not Sampled
62	28-2-546	Canal Road, Franklin Twp	Gordon Gund	3 Sept 1983	450	6	6	100	Unscreened	350	Steel	40	410	Domestic	Diabase	Not Sampled
63	28-2-548	Canal Road, Franklin Twp	Charlie Melvin	1 Dec 1954	68	30	6	30	Unscreened	38	Steel	8	15	Domestic	Shale	Not Sampled
64	28-2-548	Canal Road, Franklin Twp	Gordon Spencer	10 Aug 1975	200	40	6	53	Unscreened	147	Steel	5	160	Domestic	Red Shale	Not Sampled
65	28-2-549	Montgomery Twp	Fox-Hollow Construction Co.	10 Jan 1964	137	9	6	30	Unscreened	107	Steel	55	75	Domestic	Shale	Not Sampled
66	28-2-571	Canal Road, Franklin Twp	John C. Bullitt	28 Dec 1982	225	20	6	60	Unscreened	165	Steel	NA	NA	Irrigation	NA	Not Sampled
67	28-2-571	Franklin Twp	Charles Cherris	6 Sept 1963	90	10	6	35	Unscreened	55	Steel	15	60	Domestic	Bedrock	Not Sampled
68	28-2-578	Franklin Twp	Louis Lipot	19 Jun 1954	95	10	6	24	Unscreened	71	Steel	20	30	Domestic	Bedrock	Not Sampled
69	28-2-578	NA	Harold Burdett	18 Aug 1953	115	10	6	20	Unscreened	95	Steel	28	55	Domestic	Shale	Not Sampled
70	28-2-7	Old Hercules Powder Plant, Rocky Hill Boro	NJDEP, Water Resources	11 Feb 1983	75	6	4	21	Unscreened	54	Steel	74	NA	Monitor Well	Red Shale	NA
71	28-2-7	Old Hercules Powder Plant, Rocky Hill Boro	NJDEP, Water Resources	11 Feb 1983	75	NA	4	21	Unscreened	54	Steel	NA	NA	Monitor Well	Red Shale	NA
72	28-2-7	Franklin Twp	C. Smith	10 Aug 1970	190	15	6	50	Unscreened	140	Steel	120	25	Domestic	Shale	Not Sampled
73	28-2-71	Princeton Airport	Teterboro Aircraft Service, Inc.	10 Jun 1983	10	NA	2	10	5 to 10	0	PVC	NA	2	Monitor Well	Red Siltstone	NA
74	28-2-71	Princeton Airport	Teterboro Aircraft Service, Inc.	14 Jun 1983	15	NA	2	15	10 to 15	0	PVC	NA	6	Monitor Well	Red Siltstone	NA
75	28-2-71	Princeton Airport	Teterboro Aircraft Service, Inc.	9 Jun 1983	15	NA	2	15	10 to 15	0	PVC	NA	2	Monitor Well	Red Siltstone	NA
76	28-2-71	Princeton Airport	Teterboro Aircraft Service, Inc.	NA	NA	NA	2.5	24	Unscreened	NA	Steel	NA	NA	Monitor Well	Red Silstone	NA

TABLE 3-1, CONCLUDED

Ref. No.	New Jersey Coordinate System Location No.	Reported Address	Original Owner	Date Drilled	Total Depth (ft)	Reported Yield (gpm)	Well Diameter (in)	Length of Casing Installed (ft)	Depth of Interval Screened (ft)	Length of Open, Uncased Section (ft)	Casing and Screen Material	Depth to Static Water on Date Drilled (ft)	Depth to Pumping Water Level (ft)	Use	Aquifer	Analyses of Well Water
77	28-2-717	Montgomery Twp	Brookside Associates	9 May 1977	140	50	6	41	Unscreened	99	Steel	130	10	Domestic	Bluish-Grey Shale	NA
78	28-2-722	Montgomery Twp	George Sands	28 May 1961	134	40	6	34	Unscreened	100	Steel	100	32	Domestic	Red Shale	Not Sampled
79	28-2-724	Montgomery Twp	Walter D. Waters	31 Dec 1955	99	8	6	22	Unscreened	77	Steel	65	12	Domestic	Red Shale	Not Sampled
80	28-2-724	Montgomery Twp	Carter Inc.	10 Aug 1964	150	50	6	32	Unscreened	118	Steel	100	30	Domestic	Red Shale	Not Sampled
81	28-2-724	Montgomery Twp	Calvin J. Calbreth	5 Feb 1974	96	8	6	25	Unscreened	71	Steel	70	16	Domestic	Red Shale	Not Sampled
82	28-2-724	Montgomery Twp	M.L. Dodge, Inc.	28 May 1963	200	40	6	41	Unscreened	159	Steel	100	25	Domestic	Bluish-Grey Shale	Not Sampled
83	28-2-725	Montgomery Twp	Kammler Buic	16 Apr 1960	95	20	6	33	Unscreened	62	Steel	50	8	Domestic	Bluish-Grey Shale	Not Sampled
84	28-2-725	Montgomery Twp	Francis A. Tash	10 Oct 1954	94	15	6	22	Unscreened	72	Steel	30	8	Domestic	Red Shale	Not Sampled
85	28-2-727	Montgomery Twp	Brookside Associates	13 May 1977	160	60	6	43	Unscreened	117	Steel	100	5	Domestic	Bluish-Grey Shale	Not Sampled
86	28-2-727	Montgomery Twp	Jeannett F. Wilson	1952	88	5	6	25	Unscreened	63	Steel	70	10	Domestic	NA	Not Sampled
87	28-2-727	Montgomery Twp	Emanual Kennidy	27 Sept 1954	105	5	6	20	Unscreened	85	Steel	70	18	Domestic	Red Shale	Not Sampled
88	28-2-727	Princeton Twp	Atlantic Refining Co.	22 Feb 1962	NA	7	6	20	Unscreened	NA	Steel	90	15	Gas Station	Bluish-Grey Shale	Not Sampled
89	28-2-727	Montgomery Twp	Emanuel Kennidy	27 Sept 1954	105	5	6	22	Unscreened	83	Steel	70	18	Domestic	Red Shale	Not Sampled
90	28-2-732	Rocky Hill	Ameliotex, Inc.	1 Nov 1971	310	40	8	30	Unscreened	280	Steel	252	10	Test Well	Red Shale	Not Sampled
91	28-2-732	Rocky Hill	Young Dev-Lab, Inc.	22 May 1957	107	10	6	21	Unscreened	86	Steel	80	15	Industrial	Blue Shale	Not Sampled
92	28-2-733	Montgomery Twp	Fisher-Ancona Builders, Inc.	29 Apr 1965	118	25	6	53	Unscreened	65	Steel	100	20	Domestic	Red Shale	Not Sampled
93	28-2-734	Montgomery Twp	Roy Krupa	9 Oct 1978	165	15	6	50	Unscreened	115	Steel	120	40	Domestic	Shale	Not Sampled
94	28-2-734	Montgomery Twp	Daniel Johnson	27 Jun 1958	90	2.5	6	22	Unscreened	68	Steel	70	18	Domestic	Blue Shale	Not Sampled
95	28-2-735	Montgomery Twp	Fred E. Cruser	16 Nov 1953	76	11	6	22	Unscreened	54	Steel	50	18	Domestic	Blue Shale	Not Sampled
96	28-2-735	Montgomery Twp	Fisher-Ancona Builders, Inc.	10 Apr 1968	118	30	6	50	Unscreened	68	Steel	100	20	Domestic	Shale	Not Sampled
97	28-2-735	Montgomery Twp	Fred E. Cruser	16 Nov 1953	76	11	6	22	Unscreened	54	Steel	50	18	Domestic	Blue Shale	Not Sampled
98	28-2-879	West Windsor	Joseph Hoffman	25 Apr 1968	65	25	4	60	60 to 65	5	PVC	37	20	Domestic	NA	Not Sampled


N
MONTGOMERY ROAD
BEDEN
SYCAMORE LANE
ROBIN DRIVE
CIRCLE
CLEVELAND CIRCLE
US ROUTE 206
ROUTE 518
ROCKY HILL MUNICIPAL WELLFIELD
MILLSTONE RIVER
DELAWARE AND RARITAN CANAL
CANAL ROAD
0 1000 2000 FT
SCALE
STUDY AREA
MONTGOMERY TOWNSHIP HOUSING DEVELOPMENT
& ROCKY HILL MUNICIPAL WELLFIELD
WOODWARD—CLYDE CONSULTANTS
CONSULTING ENGINEERS GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE NEW JERSEY
DR BY FLC
SCALE AS SHOWN
CKD BY MFC
DATE 11 DEC 1987
FIG NO J 1

MGY 001 0059



LEGEND

25 WELL NUMBER CORRESPONDS TO TABLE 3–1

● LOCATION OF WATER WELL, FROM NJDEP RECORDS

0 2100 4200 FT
SCALE

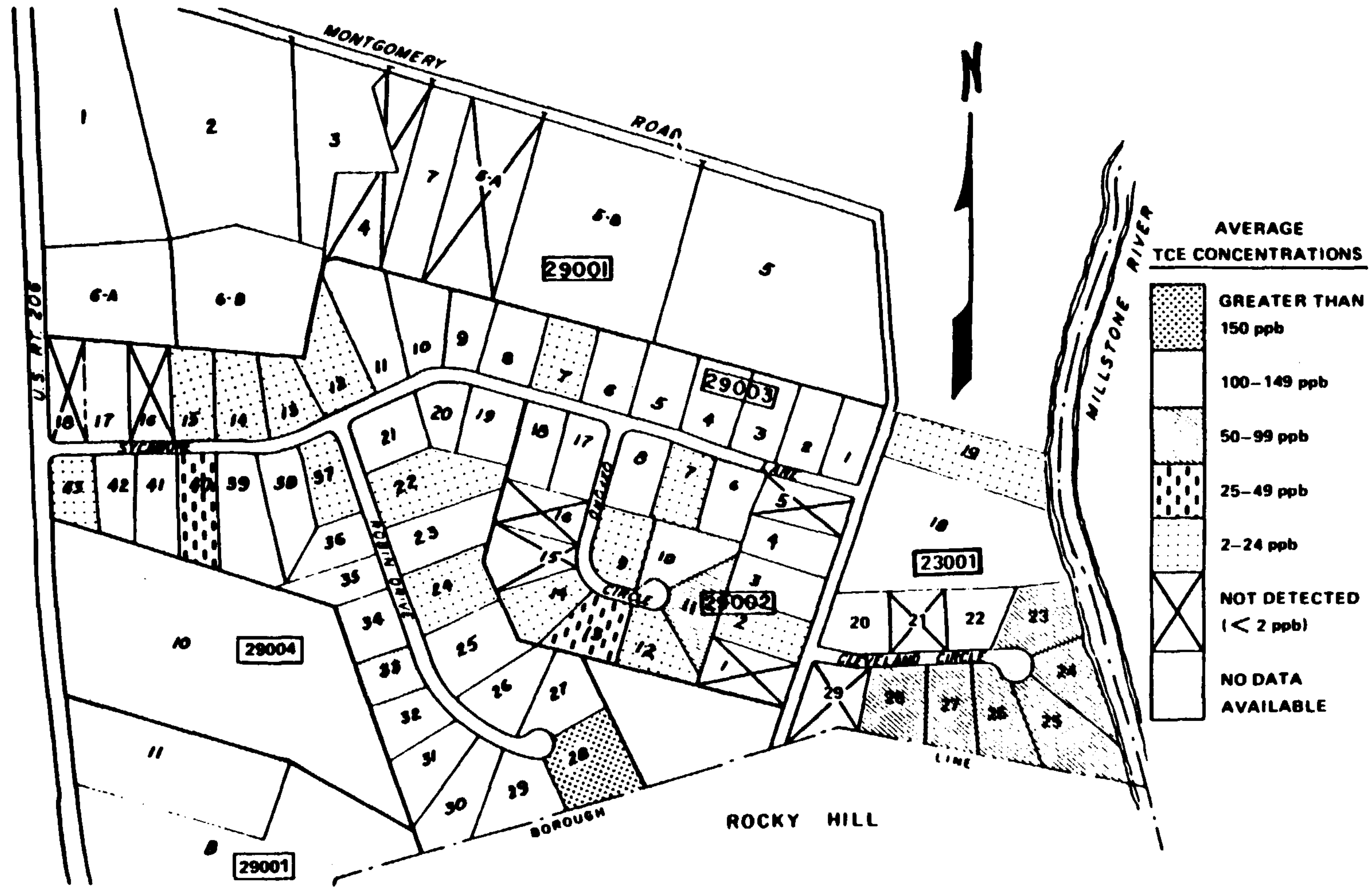
MAP SOURCE:

NJDEP, TOPOGRAPHIC SHEET NO. 28
TRENTON, NEW JERSEY. PHOTOREVISED 1957

APPROXIMATE LOCATIONS OF EXISTING WATER WELLS
MTHD/RHMW SITE
SOMERSET COUNTY, NEW JERSEY

WOODWARD—CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR. BY:	DRS	SCALE:	AS SHOWN	PROJ. NO84C4007A2M	
CK'D. BY:	GW	DATE:	11 DEC 1987	FIG. NO.:	3–2



SOURCE:
MONTGOMERY TOWNSHIP TAX MAP,
1984 RAMP BY JACA AND NUS

AVERAGE TCE CONCENTRATIONS
1979–1985
MONTGOMERY TOWNSHIP HOUSING DEVELOPMENT

WOODWARD – CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR BY DRS	SCALE 1" = 570'	PROJ NO 84C4007A2M
CK'D BY EC	DATE 11 DEC 1987	FIG NO 3-3

EPA REGION II
SCANNING TRACKING SHEET

DOC ID # 58312

DOC TITLE/SUBJECT:

PLATE 3-1
MONTGOMERY TOWNSHIP HOUSING DEVELOPMENT SITE OPERABLE UNIT 2 LOCATION PLAN MTHD / RHMW SITE: 11 DEC 1987

THIS DOCUMENT IS OVERSIZED AND CAN BE LOCATED IN THE ADMINISTRATIVE RECORD FILE AT THE

SUPERFUND RECORDS CENTER
290 BROADWAY, 18TH FLOOR
NEW YORK, NY 10007

SECTION FOUR
INVESTIGATIVE METHODOLOGIES

4.1 SITE RECONNAISSANCE

A preliminary site investigation was conducted by WCC during September, 1985. At that time, specific locations for the electrical resistivity survey were chosen, and the accessibility of the proposed monitoring well locations to drilling rigs was assessed. Further reconnaissance was done with the aid of aerial photographs. Three sets of photographs were used dated 1 October through 5 October 1956, 12 October 1971 and 13 March through 20 March 1979. These photographs were used to identify any additional information on the potential sources of contamination and, subsequently, to locate strategically the monitoring wells.

4.2 LEVELING SURVEY

A topographic and cultural feature map of the site and the adjacent Rocky Hill Municipal Wellfield site was prepared by Lau and Shaburnia in June, 1986. Elevations were surveyed to an accuracy of 0.01 foot and were referenced to a USGS bench mark. Once the monitoring wells were installed they were subjected to a horizontal and vertical-control survey. Vertical survey data are included on boring logs (Appendix C) and monitoring well installation reports (Appendix D). Horizontal survey data was used to position well locations onto the base map. The completed map is included as Plate 3-1 of the report.

4.3 SOIL AND ROCK INVESTIGATION

4.3.1 Geophysical Survey

21

The geophysical investigation performed at the site on 7 and 8 November and 3 December 1985 consisted of resistivity profiling and resistivity sounding methods of subsurface investigation. The primary objective of the geophysical investigation was to investigate the presence and orientation of highly fractured zones which could act as significant water-bearing conduits. Areas were chosen for study based on findings from the lineament study (Section 4.3.2).

Electrical resistivity methods provide a means of subsurface exploration by direct electrical measurements taken at the surface of the earth. Typically, for both profiling and sounding techniques, four electrodes are pushed into the ground to a depth of several centimeters at selected known distances away from a centralized measurement point. Electrical current, of a known amperage, is applied to the ground surface using the two outside or "current" electrodes. The resulting voltage drop (potential difference) produced by this current in the earth is measured across the inside pair of "potential" electrodes. Because some earth materials are better conductors of electricity than others, as a result of material type, moisture content, dissolved salt or ion content, etc., the voltage drop will be affected differently by various subsurface materials.

The resistivity profiling in this investigation used the Schlumberger electrode configuration. This configuration consisted of a symmetrical, colinear, four electrode array where the distance between the outer current electrodes greatly exceeded the distance between the inner potential electrodes. For this investigation current electrode to current electrode distances ranged from 300 to 400 ft, whereas the distance between potential electrodes was either 10 to 20 ft. The resistivity soundings in this investigation used an offset Wenner electrode configuration. The standard Wenner array uses four equally spaced electrodes. The offset Wenner adds a fifth electrode at the same spacing, known as the "A" spacing. Field instrumentation for this investigation consisted of a Terrameter SAS 300 transmitter/receiver resistivity unit manufactured by Atlas Copco of Bromma, Sweden. The Schlumberger profiling used four individual cables and electrodes. The offset Wenner soundings used the Barker-Bison multi-core cable system manufactured by Bison Instruments of Minneapolis, Minnesota.

The field investigation performed on 7 and 8 November was initiated by field location of the sites as shown on the regional areal photograph. After field identification of the proposed lineaments, Schlumberger profiling was conducted over a horizontal distance of approximately 200 to 300 ft in order to completely span the primary investigation area. This profiling was aligned approximately perpendicular to the proposed lineaments in the attempt to maximize the potential resistivity contrasts across the site. The locations for the Wenner soundings were then selected based on preliminary analysis of the Schlumberger profiling. The choice of each location was based on the observation of anomalously high or low potential variation of the Schlumberger data, and on the need for full coverage of the site areas. The orientation of the sounding arrays was parallel to the proposed lineaments to maximize the lateral consistency of the subsurface layers below the sounding point.

The field investigation performed on 3 December 1986, consisted of Wenner soundings at six locations. A minimum of three soundings were performed at each location. Soundings were orientated along the profile traverse and at stations separated by approximately 40 ft. These measurements were performed to supplement the information obtained during profiling.

The areas studied are as follows:

- between Montgomery Road and the Millstone River (Line #1)
- between Montgomery Road and River Road (Line #2)
- between Cherry Hill Road and Princeton Airport (Line #3)
- area bordered by Route 206 and Robin Drive

4.3.2 Lineament Analysis

The purpose of the lineament study was to identify surface expressions of underlying bedrock features such as fractures, bedding planes, joints, etc., which might be influencing ground water flow patterns in the site area. Lineaments were identified on 18 aerial photographs centered on the town of Rocky Hill, New Jersey, within an area of more than a 1-mile radius. The photographs were taken in March 1979. Each photograph was examined independently by two operators, one of whom was not aware of the nature of the problem, the reasons for the study, or the geology of the area. Lineaments were marked on two sets of transparent overlays. The two sets were then compared, and apparent man-made lineaments were eliminated, where possible. Remaining lineaments suspected to be man-made were checked in the field, and additional eliminations made. At the same time, the orientation of bedrock fractures was measured at the few outcrops available in the area. Remaining lineaments were compiled on an overlay of a photomosaic and transferred to a topographic base map at a scale of 1:24,000. Lineament orientations were plotted on a rose diagram (semi-circular histogram) in 10° increments.

4.3.3 Monitoring Well Borings

Borings made for the purpose of installing monitoring wells were logged by WCC field inspectors. Boring logs are included in Appendix C. Well installation reports are included in Appendix D. Information recorded on boring logs was used to interpolate subsurface conditions at the site.

4.3.4 Soil Source Borings

Thirty-three borings were made for the purpose of sampling soil for chemical analyses (Plate 3-1). Boring locations were chosen based on round one sampling and historical data and were finalized after consultation with NJDEP personnel.

Thirteen of these borings were advanced to a depth of approximately 12 ft immediately adjacent to and downgradient from septic leach fields. The depth chosen for these borings was based on the fact that septic leach fields are buried generally 4 through 5 ft below ground surface. Thus, in the immediate vicinity of the field leachate should occur at shallow depths. The remaining borings were advanced to depths of 20 ft or less depending on the depth at which bedrock was encountered. Split spoon samplers were field decontaminated between samples as described in Section 12.2 of Appendix A of the QAPMP for this site with the addition of a 10 percent Nitric acid rinse where samples were to be analyzed for metals.

Samples to be chemically analysed were selected based on headspace analysis results. At the time of collection each soil sample was split and placed into two different jars. One jar was sealed with foil, capped and placed on ice to be used for headspace analysis. The second jar was a laboratory cleaned sample jar which was capped and placed on ice potentially to be sent to the laboratory for analysis. Once a boring was completed, all of its samples underwent headspace analysis using an organic vapor analyzer (OVA) equiped with a gas chromatography column and a strip chart recorder. The sample or samples showing the highest concentrations of volatile compounds were sent to the laboratory for analysis. One sample was selected from each shallow boring and two were selected from each deep boring. Samples from shallow borings were anlayzed for priority pollutant volatile organic compounds plus 15 additional peaks. One sample from each of the deep borings was analyzed for volatile organic compounds. The second sample from each of the deep borings was analyzed for either volatile organics or for priority pollutants and 40 additional peaks depending on the perceived liklihood of finding non-volatile organics in a given boring.

4.3.5 Stream Sediment Sampling

In order to determine whether contaminated ground water is discharging into nearby surface waters and contaminating their sediment beds, sediment samples were collected from five locations in the Millstone River and in a tributary to the Millstone south of Route 518 (Plate 3-1). Samples were collected using laboratory cleaned sample containers to scoop up sediment. Sediment samples were placed on ice and shipped to the laboratory on the day of sampling to be analyzed for priority pollutant volatile organic compounds plus 15 additional peaks.

4.4 GROUND WATER INVESTIGATION

4.4.1 Construction of New Monitoring Wells

Thirty monitoring wells were installed in the site area. Locations of wells are shown in Plate 3-1. Two types of wells were installed. Shallow wells were intended to monitor ground water in the weathered portion of the bedrock. These wells are 4.0 in. in diameter and are screened. Deep wells were intended to monitor ground water in the competent bedrock at greater depths. With the exception of well MW-3D, deep monitoring wells are 6.0 in. in diameter, and are open-hole wells. Due to collapse of the borehole, monitoring well MW-3D was installed with a cased upper section and a screened intake section. Shallow wells extend to depths from 20 to 82 ft below ground surface. Deep wells extend to depths from 100 to 250 ft below ground surface.

Well installation reports are included in Appendix D of this report. All monitoring wells were installed in accordance with procedures described in Section 5.0 of Appendix A of the Quality Assurance Project Management Plan for this site. All of the deep wells were developed by air lifting. Most shallow wells were developed initially by air lifting followed at a later date by water jetting. Wells MW-16, MW-17, MW-18 and MW-19 were developed by pumping. Rocky Hill Municipal Well water was used for all well installation operations.

4.4.2 Aquifer Testing

In order to characterize the aquifer beneath the site three testing methods were employed: water level surveys, permeability tests in individual wells and an aquifer pumping test using observation wells. Water levels in monitoring wells were measured on several occasions to determine the potentiometric surface of the aquifer and to record seasonal variations.

On 13 December 1986 a short duration pumping test was performed using the Rocky Hill municipal well as the pumping well. Drawdown from pumping was observed in the surrounding new monitoring wells. Pumping in the municipal well was discontinued 14 hours before the pumping test started so that the water could recover to its static level. Pumping of the municipal well lasted for 6 hours and was followed by a recovery period of 3 hours. Personnel from WCC monitored water levels during both the drawdown and recovery periods. Larry Merk, Rocky Hill's Water Supervisor, operated and monitored the pumping equipment within the well house. All ground water withdrawn from the well was run through the air-stripper, and then it was either stored for municipal distribution or discharged into a nearby storm sewer. All depth-to-water measuring devices (electric sounding probes) and clocks used were calibrated and synchronized. Water level readings within the pumping well were obtained by a previously installed direct reading gauge.

Field permeability slug tests were conducted to estimate the hydraulic conductivity (permeability) of the soil/rock strata within the screened interval of each well. The test consisted of measuring the rate at which the water level rose in a monitoring well after a certain volume or 'slug' of water was suddenly removed from the well (rising head tests). Since the volume of water removed from each well is very small compared to the volume of water in the surrounding aquifer, the slug test is an estimate of permeability within only a few foot radius of the well intake. The data also tend to mask changes in the vertical distribution of the permeability by yielding one average value over the entire saturated length of the well screen.

Essentially instantaneous lowering of the water level was achieved by lowering a stainless steel submersible pump several feet below the initial water level, letting the water level reach equilibrium for up to 20 minutes, and then pumping water quickly from the well. When the water level was lowered to pumping level (i.e., when the discharge of water from the hose ceased) the pump was stopped and removed. To minimize the vertical component of flow to the well, less than 5 percent of the initial water volume was removed. A submersible pressure transducer and an electronic recording device were used to record continuously water level changes versus time.

4.4.3 Ground Water Sampling

Twenty-three monitoring wells were sampled in late November and early December 1986. All but three were new wells installed by WCC. Six wells (MW-4S, MW-5S, MW-6S, MW-9S, MW-10S and MW-15S) which had been installed by WCC were dry at the time of sampling and were, therefore, not sampled. A second round of monitoring well sampling was conducted between 30 June 1987 and 15 July 1987, and a recently installed well was sampled on 18 August 1987. Thirty wells were sampled during this period. Two wells (MW-4S and MW-5S) were dry at the time of sampling. Two of the wells sampled had been installed by others prior to the initiation of this study: a NJDEP monitoring well north of the Village Shopper complex, and a production well at 1377 Route 206.

Each of the wells was purged of three well volumes no more than 2 hours prior to sampling (or pumped dry). Purging was done with either a submersible or centrifugal pump depending on the depth to water level.

Samples were collected using dedicated stainless steel bailers with either teflon or stainless steel leaders attached. Prior to use each bailer was laboratory cleaned and wrapped. Sampling procedures were conducted in accordance with those outlined in Section 7.3 in Appendix A of the Quality Assurance Project Management Plan for the site.

4.4.4 Domestic Well Sampling

On the fifth and sixth of June 1986, 35 domestic wells were sampled in and around the Montgomery Township Housing Development. The selection of wells was based on their proximity to previously identified areas of contamination. Locations of the domestic wells are included in Plate 3-1. Prior to sampling, each of the wells was evacuated until the pH, temperature and conductivity of the water was stable. This corresponded to an average evacuation time of approximately 30 minutes. All of the wells were sampled from outdoor taps which protrude from the building foundations. Water treatment devices were shut off prior to evacuation. Sampling procedures were in accordance with those outlined in Section 7.2 in Appendix A of the Quality Assurance Project Management Plan for this site.

To verify the presence of low levels of contaminants in three domestic wells, resampling was conducted on 22 April 1987. Also at this time, two domestic wells in Rocky Hill were sampled. Sampling procedures during this sampling episode were identical to those described above.

4.5 SURFACE WATER INVESTIGATION

In order to determine whether contaminated ground water is discharging to nearby surface water bodies, samples were collected from five locations in the Millstone River and in a tributary of the Millstone, south of Route 518. Samples were collected directly into laboratory cleaned sample containers. Non-preserved containers were used to fill those containing preservatives. Samples were shipped on ice on the day of sampling to the laboratory to be analyzed for prioirty pollutants plus forty additional peaks.

4.6 SEPTIC TANK INVESTIGATION

In order to determine if local septic tanks might be contributing to ground water contamination samples were collected from seven tanks (Plate 3-1). Sampling locations were chosen based on the known extent of contamination. Samples were collected by removing access lids and lowering stainless steel, laboratory cleaned bailers with stainless steel leaders into the tanks. Samples were stored on ice and shipped to the laboratory to be analyzed for priority pollutant volatile organics compounds plus 15 additional peaks.

4.7 AIR QUALITY INVESTIGATION

WCC conducted an air quality survey of potential contamination source locations at the MTHD/RHMW Site. The purpose of this survey was to locate and identify possible sources of volatile contaminants in the area. On 14 and 21 April 1987 ambient air quality was sampled at the location of 13 PRPs as identified by the project plans.

The air quality survey was performed using a photoionization detector (HNU) calibrated to benzene. Potential sources and pathways of contaminants in the area were identified during the survey by a Health and Safety Officer and a Hydrogeologist. Once identified, an HNU reading of the potential source was made by holding the instrument tip within 6-in. of the sampling site to effectively reduce atmospheric variations. Background readings were obtained by taking HNU readings while holding the instrument tip about 10 ft away from the sampling site. Draeger colorimetric tubes for trichloroethene and vinyl chloride were available to identify these specific compounds if HNU readings exceeded 5 ppm total organic vapors.

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SECTION FIVE
DATA PRESENTATION AND ANALYSIS

5.1 SOIL AND ROCK INVESTIGATION

5.1.1 Geophysical Survey Results

Field data from the resistivity profiles and soundings were processed to obtain apparent resistivities of subsurface features and to interpret underlying structure and stratigraphy. This information was further processed to obtain values of longitudinal conductivity and transverse resistivity, parameters which have been shown to relate to hydraulic conductivity and, in some cases, to water saturated permeable zones. These values were then evaluated as a function of depth to investigate where the rate change of these parameters changed with depth. Increases (or decreases) in this rate of change were used to signal and isolate more (or less) "transmissive" zones, which were interpreted to be either saturated zones or hard/tight zones in the Brunswick Formation. Results of the survey are summarized below and graphically in Appendix E.

Results of the traverse along line No. 1 (Figure 5-1) suggest that the lineament expressed on the surface in this area may be related to a water-saturated fracture system dipping at approximately 25 degrees towards the southwest.

Data from the traverse along line No. 2 (Figure 5-1) suggest a near surface zone of wetness in weathered rock and a horizontal fracture zone containing water at approximately 60 to 90 feet below the ground surface.

Results of the survey along line No. 3 suggest a near-vertical water saturated zone in that area.

Results of the soundings in the area between Route 206 and Robin Drive are depicted in Figure F-14 of Appendix F and as a recumbent diamond symbol in Figure 5-1. The findings suggest a water saturated vertical fracture system trending approximately 65 degrees east of north. The data also suggest a near surface water saturated horizontal fracture system.

5.1.2 Lineament Study Results

The majority of the lineaments identified fit into three groups. The largest number have trends which range in azimuth from 50 to 70 degrees. The second and third most numerous groups of lineaments trend 270 to 290 degrees and 10 to 20 degrees (Figures 5-1 and 5-2).

The latter groups were observed in the field and represent bedrock fractures with dips ranging from moderately steep to vertical. Bedding planes observed in the field strike 40 to 50 degrees. Because only four lineations were found to have similar orientations to the bedding plane, it is concluded that the lineation fabric represents bedrock fractures which are not parallel to bedding. Based on these data, the maximum transmissivity along bedrock fractures in the Brunswick aquifer should be aligned mainly northeastward to eastward with lesser components towards the north-northeast (or 180 degrees from these directions depending on regional flow directions).

5.1.3 Boring Logs

The boring logs (Appendix C) indicate that most of the site is underlain by a thin veneer (generally less than 4 ft) of mainly dark reddish brown sand with varying amounts of clay, silt and gravel. Some areas of the site are underlain by brown and mottled yellow, orange and brown sands which are probably glacial till materials. This overburden rests on top of deeply weathered dark reddish brown mudstone. The mudstone's hardness and strength increases with depth below the ground surface. The thickness of the mudstone in each of the boring locations varies. Similarly, the underlying stratigraphy varies between locations. The rocks consist mainly of reddish brown siltstone, claystone and sandstone. Lesser amounts of calcareous mudstone and siltstone are also present. Thin beds (less than 10 ft) of argillaceous limestone and dolostone are present in most boring locations. An attempt to correlate stratigraphic layering between borings was not possible suggesting that these units are not laterally continuous. Most of the rock cores contained close to moderate fracture spacing.

5.2 GROUND WATER INVESTIGATION

5.2.1 Physical Characteristics

5.2.1.1 Water Elevations. Water level measurements were used to determine ground-water flow patterns in the site area. Because of the effect of pumping of the Rocky Hill Municipal Well (RHMW) on water levels in some of the deep wells, only the 13 December 1986 measurements are believed to represent essentially true ground water patterns in the area (see Section 5.2.1.2). These measurements were made just after RHMW had been shut off for 14 hours, allowing water levels to recover to their static or near-static conditions (Table 5-1). Measurements from shallow and deep wells under these assumed static conditions indicate that several water-bearing zones are present which are separated by less permeable (or lower fracture density) units. The deeper zones may be unconfined or semi-confined. A water-table aquifer is intercepted by the shallow wells and occurs at depths ranging from less than 3 to more than 40 ft beneath the ground surface. Ground-water elevations in shallow wells are uniformly higher than the deeper wells. Head differences between shallow and deep wells indicate a potential for downward vertical movement of water. Fractures identified by the geophysical survey may facilitate vertical movement.

Contours of the piezometric surfaces based on static level measurements are shown in Figures 5-3 and 5-4. Water table contours appear to follow topographic contours of the site. In general, ground water in the water-table zone of the aquifer flows towards the northeast but diverges along a northeast trending axis throughthe center of the Housing Development and flows toward the east and northwest. Shallow ground water flows from the site toward two surface water bodies: the Millstone River to the east and Beden Brook, a tributary of the Millstone, to the north. The water table elevations in the shallow wells near Beden Brook and the Millstone River aproach the elevations of these surface water bodies, suggesting that shallow ground water discharges into these rivers. Both of these rivers flow toward the north and join just beyond the study area. Apparent water table gradients interpolated between monitoring wells are gentler toward the northwest and are steeper (up to 0.03 ft/ft) toward the northeast.

Water elevation contours based on measurements from the deep wells show a similar pattern to those based on shallow wells. The primary differences between the two are that the piezometric surface for the deep aquifer has a slightly steeper gradient and less well defined divide between eastward and northwestward flow. A typical gradient reflected by the water elevations in the deep wells is 0.03.

As stated above, the conditions described represent essentially static levels. In order to evaluate more typical conditions, consideration must be given to the effects of pumping at the RHMW. On the average, the RHMW is pumped for 2 to 3 hours aproximately three times a day (larry Merk, personal communications, 5 November 1986). The zone of influence after 3 hours of continuous pumping is defined roughly by an ellipsoid whose primary axes are 4,000 ft and 2,000 ft long and whose long axis trends northeast (Figure 5-5).

Seasonal variations may be deduced by observing wells which are known to be unaffected by pumping at the RHMW (Table 5-1). These measurements indicate that the shallow and deeper zones of the aquifer show no discernible pattern of seasonal variation between the summer and winter months. Figures 5-7 and 5-8 depict ground water elevation contours based on measurements made in August 1987 for comparison with figures based on December elevations. It should be noted that it is not known if or when the RHMW was pumping while the August measurements were taken.

5.2.1.2 Pumping Test. The purpose of the pumping test was to: estimate the transmissivity of the bedrock aquifer; investigate whether the deeper water-bearing zones in the bedrock aquifer and the overlying shallow water-table aquifer are hydraulically directly connected; find the radius of influence of the municipal well; and gain a better understanding of the flow system being examined.

Pumping test data are included in WCC's summary report of the pumping test (WCC, March 1987). Effects of pumping on the ground water elevations and piezometric surface are illustrated in Figures 5-5 and 5-6. Pumping of the RHMW well was found to affect the water levels in six of the deep monitoring wells; MW-7D, MW-9D, MW-10D, MW-11D, MW-13D and MW-15D. (MW-13D only exerienced a minor drawdown of 0.3 ft. None of the shallow wells was influenced by pumping during the 6 hours of the test. The "radius of influence" of the pumping well extended further to the southeast (about 2000 ft) than it did to the north (about 1000 ft).

Drawdown data at each observation well were analyzed using three different methods. All wells which exhibited drawndown were subjected to a Theis type curve analysis, assuming radial flow, a homogeneous aquifer of infinite areal extent and a fully-penetrating fracture in an isotropic aquifer. Plots for all three methods are included in Appendix G.

The Theis method is a nonequilibrium well function equation and takes into account the effect of pumping time on well yield. Values of drawdown versus time are plotted on log-log scale and graphically matched with the theoretical type curve of the well function W(u) versus u. The similarity variable u is defined as:

$$u = \frac{1.87 \quad r^2 S}{Tt}$$

where r is distance in feet (radially from the pumping center), S is the coefficient of storage (dimensionless), T is the coefficient of transmissivity in gpd/ft and t is the time since pumping began in days. W(u) is an exponential integral derived from heat flow theory.

Because drawdown can be expressed as:

$$s = \frac{114.6 \; Q \; W(u)}{T}$$

where s is drawdown in feet and Q is discharge in gpm, we can calculate transmissivity using:

$$T = \frac{114.6 \; Q \; W(u)}{s}$$

Storage coefficient can then be estimated by:

$$S = \frac{u \, T \, t}{2693 \, r^2}$$

with t being time in minutes.

The Jacob method is a simplified version of the Theis method of pumping test data analysis. The method makes the assumptions listed above regarding the aquifer and well characteristics and has the further limitation that it should only be used when the well function similarity variable, u, is less than 0.01.

According to theory, data with similarity variable values less than .01 should plot as a straight line when the log of time is plotted against the drawdown. The slope of this straight line can then be used to determine aquifer transmissivity. The intercept of the straight line is an indicator of the storage coefficient of the aquifer. The equations for the transmissivity and storage are:

$$T = \frac{264Q}{\Delta s}$$

$$S = \frac{Tt_o}{4790\ r^2}$$

where Q is the pumping rate (gal/min), is the drawdown per log cycle of time (ft), t_o is the time at the point where the straight line intersects the zero-drawdown line (min), and r is the radial distance between the pumping well and the monitoring well (ft).

It is likely that the assumptions of the Jacob method were not all realized during the Rocky Hill pump test. However, by making semi-log plots of time vs drawdown for each observation well and noting which data sets plot as a straight line, it is possible to determine the locations where radial flow towards the pumping well appears to occur. At the locations where radial flow does occur, transmissivity can then be approximated by the standard Jacob method.

The method developed by Jenkins and Prentice (1982) is for determining hydraulic parameters of a fractured-rock aquifer. The method is applicable to linear flow toward a fully-penetrating fracture. The Jenkins-Prentice analysis indicates that in regions where such linear flow predominates, a data plot of drawdown against the square-root of time should yield a straight line. Conversely, it is, therefore, possible to determine where linear flow toward fractures occurs in an aquifer by plotting drawdown against the square-root of time at each observation well and finding out for which wells straight lines result. Once such straight-line plots are found, the transmissivity can be found from

$$\frac{T}{S} = \frac{\pi x^2}{4t_o}$$

where x is the perpendicular distance from the fracture to the observation point.

Data from all wells which experienced significant drawdown were plotted as drawdown vs log time and drawdown vs square-root of time-curves. A linear relationship between drawdown and log time was found for the pumping well and wells MW-9D and MW-10D. A linear relationship between drawdown and the square root of time was found for wells MW-7D, MW-11D and MW-15D. A Theis type curve match was performed for wells MW-9D, MW-10D and the pumping well, but a match was not possible for wells MW-7D, MW-11D, and MW-15D. These results seem to indicate that the aquifer flow in the region of two former wells is toward the pumping well, whereas flow in the vicinity of the three latter wells is toward fracture(s).

Aquifer transmissivities and storage coefficients computed using the Jacob method are summarized in Table 5-2 and H-2. The transmissivities were computed directly from the semi-log plots given in Appendix H. (The plots given in Appendix G were chosen because of their high correlation coefficients.) Theis match results for transmissivity are similar and can also be found in Table 5-2 and H-1. It should be noted that no values for the permeability of the aquifer are reported in these tables. Permeabilities are normally found by dividing the transmissivity by aquifer thickness. However, in a fractured bedrock aquifer, the aquifer thickness is not a well-defined parameter. Therefore, it is felt that it is more appropriate to leave the pump test results in terms of apparent transmissivity. Fracture permeability is likely to vary by several orders of magnitude, but on an area wide basis, we are interested in apparent transmissivity or the averaged ability to transmit water through a unit section of the aquifer. There is a considerable difference between the values of storage coefficient derived from the Theis and the Jacob methods. The Theis method results are considered to be more reliable.

Aquifer transmissivities computed using the Jenkins-Prentice method are summarized in Table 5-3. The distance of the observation wells from the fracture, ('x' in the Jenkins-Prentice equation) was found for the relevant wells by assuming that a major fracture (or fracture zone) passes through the pumping well location and strikes approximately N45°E (southwest - northeast). The distances from the observation wells to this assumed fracture were then found by drawing the fracture on the site map and measuring orthogonal distances to relevant observation wells. It should be noted here that the Jenkins-Prentice method for finding transmissivity requires assumptions about fracture location. Because there is very little actually known about fracture locations at the Rocky Hill site and the actual pathways of flow to individual wells, the results of the Jenkins-Prentice method of analysis should not be considered very accurate. In this application the prime value of the Jenkins-Prentice method lies in the fact that it indicates the areas in which flow may be linear (i.e. fracture - controlled and anisotropic) as opposed to radial.

The following conclusions are suggested by the pumping test results. First, a direct hydraulic connection between the shallow and the deep aquifer in the vicinity of the RHMW was not apparent during the 6-hour duration of the pump test. Second, flow in the aquifer as a result of pumping seems to occur in two different modes: linear flow toward fracture zone(s) and radial flow toward the pumping well. Third, the "radius of influence" of the pumping well extended further south (about 2000 ft) than it did north (about 1000 ft). Finally, the measured transmissivity of the bedrock aquifer from the Jacob method of analysis ranged from 7.9×10^3 to 9.4×10^3 gal/day/ft. Theis analysis results ranges from 6.4×10^3 to 7.8×10^3 gal/day/ft. The transmissivity as calculated using the

Jenkins-Prentice method ranged from 3.3×10^3 to 6.4×10^3 gal/day/ft. The storage coefficient for the deep aquifer appears to be on the order of 10^{-2}.

5.2.1.3 Permeability Tests. Upon completion of the installation of the wells, it was observed that for all wells the static water level occurred within the screened interval of the shallow wells or within the uncased open hole of the deep wells. In addition, several of the shallow wells were observed to be dry. Therefore, standard slug test procedures are inappropriate.

Consequently, data from the rising-head tests in shallow wells were reduced using equations from Cedergren (1977) for determining hydraulic conductivity for shallow wells with various shape factors. The formula used has a shape factor which best fits the shallow monitoring wells installed. In this case,

$$K = \frac{R}{16DF} \times \frac{h_2 - h_1}{t_2 - t_1} \quad \text{for } \frac{D}{R} < 50$$

where K is the hydraulic conductivity; R is the well radius; D is the height of the water column in the well; F is the shape factor coefficient; h_1 is the depth to the water level at time t_1; and h_2 is the depth to the water level at time t_2. The shape factor coefficients were estimated using Figure 2.16 in U.S. Dept. of Navy (1974).

The data reduction method used for calculating aquifer properties from the shallow wells is not applicable to the deep wells because of constraints on the shape factor. The Theis non-equilibrium method was used for calculating transmissivity for the deep wells. The slug test data for the deep wells were analyzed as a short-term recovery test, by plotting residual drawdown, s', versus time since pumping ceased, on a log-log scale. Residual drawdown is defined as the difference between the equilibrium water level and the water level at time t. Transmissivity of the aquifer is obtained from these plots using the Theis type curve matching method. Pumping rate was calculated from the duration of the test and the total volume of water discharged.

In addition, data from all the slug tests were also entered into WCC's computer program SLUGT which computes the hydraulic conductivity using the method developed by Bouwer and Rice (1976). The hydraulic conductivity is calculated using the following formula:

$$K = \frac{r_c^2 \ln (Re/r_w)}{2Lt} \ln \frac{Y_o}{Y_t}$$

where K is the hydraulic conductivity ; t is time, L is the length of screened section of well casing; r_w is the radius of the borehole; r_c (corrected) is $[r+n\ (r_w^2 - r^2)]^{1/2}$ for the case where the water level occurs within the well screen of radius r and gravel pack of porosity n; Re is the effective radius over which the head difference is dissipated: rc is the horizontal distance between the well center and the undisturbed strata; and Y_o - Y_t is the vertical distance between the water level in the well after the removal of water and the equilibrium water level. Values of Re are estimated using the Bouwer and Rice (1976) electric resistance analog analysis. Data for SLUGT program are included in Appendix H.

The Bouwer and Rice (SLUGT) method requires that the total saturated thickness of the aquifer be known in order to compute hydraulic conductivity. In the case of the Brunswick Formation, aquifer thickness is difficult to define. Not only is the bottom of the aquifer uncertain, but the connectivity and vertical extent of the water-bearing zones may be laterally variable. To solve the Bouwer and Rice method, the total height of the water column in the well was used for the saturated thickness. Although this may not be accurate, it permits a comparison between this method and the other slug test solution approaches. Similarly, the apparent transmissivity computed using the Theis type curve method was converted to hydraulic conductivity using the height of the water column in the well.

Results of the slug test are summarized in Table 5-4. In order to compare the three methods, hydraulic conductivity was computed from transmissivity using the height of the water column in each well. The agreement between the methods used on each well is very good. Wells MW-1S, MW-4S, MW-5S, MW-6S, MW-13S, and MW-15S were dry or contained too little water to perform slug tests. Wells MW-9S, MW-9D, MW-10S, MW-10D, MW-11S and MW-11D were under unsteady water level conditions prior to slug testing due to the influence from the pumping of the Rocky Hill municipal well. Data from wells MW-1D, MW-2S, MW-3D, and MW-5D were unreliable and were not evaluated by analytical methods. In general, the transmissivity values computed from the hydraulic conductivities in Table 5-4 and the height of the water column are about an order of magnitude smaller than the transmissivities obtained from the pumping test.

A fourth method of interpreting the slug tests was also applied to the deep well data. As described by Driscoll (1986), recovery data may be used to obtain transmissivity in the vicinity of the well by plotting s' versus log t/t', where t is the time since the start of pumping and t' is the time since pumping ceased and well recovery began. If the aquifer meets the assumptions of the Jacob method, these data should plot as a straight line. However, plots of this type plotted as concave upward curves, (see example plot of MW-2D in Appendix H). This suggests that the aquifer, as expected, does not behave like a homogeneous porous medium. Rather, the results suggest that the water-bearing fractures are of limited lateral extent, and that recharge or recovery appears to occur, at least in part, by release of water from overlying fractures. The combination of these two effects gives rise to the appearance of a variable transmissivity.

5.2.2 Chemical Characteristics

5.2.2.1 In-Situ Measurements. Measurements of pH, electrical conductivity and temperature were obtained in the field at the time of ground water sampling, as described in Section 4.4.3. Results of these measurements are shown in Table 5-6.

The pH of the monitoring wells during first round sampling ranged from 5.0 in MW-4S airport to 12.2 in MW-3D. However, the high pH of MW-3D may be due to contamination of the ground water by cement grout, and the high conductivity of this well appears to corroborate this. During second round sampling pHs ranged from 4.2 in MW-11S to 12.6 in MW-3D. Measured pHs of the monitoring wells do not appear to vary in any regular fashion horizontallly across the site (Figure 5-7). The shallow monitoring wells are consistently of a lower pH than the paired deeper well with one exception. During second round sampling shallow well MW-9S had a pH of 6.8 while MW-9D had a pH of 6.4.

Similarly, electrical conductivity and temperature do not appear to vary regularly across the site. Deeper wells were generally one to two degrees cooler than the paired shallow well during first round sampling. During second round sampling deeper wells were again cooler than the shallow in seven out of nine well pairs sampled. Exceptions were the MW-7 and MW-13 pairs. Electrical conductivity is not consistently higher in either the deep or shallow of the paired wells.

5.2.2.2 Analytical Results. Twenty-three monitoring wells were included in the first round sampling program and thirty in the second. These samples were collected and analyzed as described in Section 4.4.3. First round ground water samples were analyzed for priority pollutant compounds plus forty additional (tentatively identified) compounds. Second round samples were analyzed for priority pollutant volatile organic compounds plus fifteen additional compounds. The results of these analyses are presented in Appendices F and G discussed below.

The most common priority pollutant organic compound found in first round ground water samples in high concentrations was trichloroethene. Other priority pollutant organic compounds found above detection limits included: trans-1,2-dichloroethene, tetrachloroethene, chloroform, acetone, methylene chloride, bis(2-ethylhexyl) phthalate, diethylphthalate, chlordane, and total phenols. Of these compounds, methylene chloride and bis (2-ethylhexyl) phthalate were also detected in the field and trip blanks, and acetone was used in field decontamination of water level meters. This suggests that these compounds in ground water samples are laboratory or field artifacts.

Trichloroethene in first round monitoring well samples ranged from below detection to 650 ug/l (Table 5-7). The highest TCE concentrations were detected in MW-7D and MW-7S. This well pair also contained significant (>20 ug/l) amounts of tetrachloroethene and trans-1,2-dichloroethene. More than 10 ug/l TCE was also detected in MW-2D, MW-3D, MW-3S, MW-4D, and MW-9D.

The most commonly found volatile priority pollutant compound found in second round ground water samples in high concentrations was trichloroethene. Other volatile compounds found above detection limits included: 1,1-dichloroethane, methylene chloride, tetrachloroethene, trans-1, 2-dichloroethene, and 1,1,1-trichloroethane. Methylene chloride appeared in only one sample at a low concentration and was also detected in field, trip and laboratory blanks. This suggests that methylene chloride is a laboratory artifact rather than a site contaminant.

Trichloroethene in second round samples ranged from below detection to 630 ug/l (Table 5-7). The highest TCE concentrations (≥150 ug/l) were found in MW-4D, MW-17, MW-3D, MW-7S, MW-7D and 1377-P.

The tentatively identified compounds detected in round one and two monitoring well samples are summarized in Appendices F and G, respectively. Tentatively identified compounds are those forty compounds which appear on the Gas Chromatograph-Mass Spectrometer in relatively high concentrations (large peaks) but are not on the USEPA Priority Pollutant List. The compounds are identified by best-fit comparison with a computer library and their identification is, therefore, considered tentative. With few exceptions, the estimated concentrations of these compounds are less than 50 ug/l. One exception is 1,1,2-trichloro-1,2,2-trifluoroethane in MW-15D during first round sampling. All other tentatively identified compounds detected at more than 50 ug/l are associated with the field and trip blanks. Similar results were obtained during second round sampling. At this time, MW-15D contained 130 ug/l of 1,1,2-trichloro-1,1,2-tri-fluoroethane. All other compounds were detected at less than 25ug/l. No tentatively identified compounds were detected in field or trip blanks.

Several priority pollutant metals were found above detection limits in round one monitoring well samples. Analyses of ground water have been compared to drinking water standards to assist in summarizing the data. With the exception of monitoring well MW-3D, chromium is the only priority pollutant metal present in concentrations exceeding the National Primary Drinking Water Regulations (NPDWR) (Table 5-8). Chromium exceeded the NPDWR Maximum Contaminant Level (MCL) by less than a factor of 2 in two wells: MW-3S and MW-5D. Exceedances of NPDWR MCLs in MW-3D may be associated with the possible contamination of this well by grout and associated pH changes.

A number of ground water samples from monitoring wells exceeded MCLs of the National Secondary Drinking Water Regulations (NSDWR) for the parameters analyzed under round one (Table 5-8). Nearly all wells exceeded these MCLs for iron and manganese. However, zinc MCL was not exceeded in any sampled well. (See Volume 2 for further discussion of exceedances of relevant and applicable guidelines or regulations).

In general, there is no apparent correlation between the levels of organic compound contamination and priority pollutant metal contamination. For example, MW-7S and MW-7D were found to contain ground water with the highest TCE concentration, but no priority pollutant metal in these wells exceeded the NPDWR MCLs. Conversely, MW-3S and MW-5D contained chromium above the NPDWR MCL, but only MW-3S contained a detectable concentration of TCE.

Ternary diagrams of major inorganic constituents in ground water are shown in Figures 5-8 and 5-9. These diagrams were constructed by converting the concentrations of calcium, magnesium, sodium and potassium to equivalents per liter, and then normalizing these values to 100 percent. Ground water analyses from the shallow and the deep monitoring wells occupy two distinct fields on these diagrams. In general, the ground water from shallow wells is depleted in calcium and contains more sodium plus potassium relative to the deep wells. The extremely high calcium value of MW-3D may be due to contamination by grout. The sodium enrichment in the shallow wells may be due to the effect of road salting or septic system effluent on the shallow aquifer. The chemical distinction between the shallow and deep wells suggests that chemical mixing is incomplete, and therefore, shallow and deep parts of the aquifer are not in full communication.

5.3 DOMESTIC WELL INVESTIGATION

5.3.1 In-Situ Measurements

Thirty-five domestic wells were included in Round 1 of sampling on 5 and 6 June 1986. Three wells containing below-detection-limit concentrations of TCE during first round sampling were resampled and analysed at lower detection limits during second round sampling (22 April 1987). Second round sampling also included two wells in Rocky Hill. Measurements of pH, electrical conductivity and temperature were obtained from domestic well water samples as described in Section 4.4.4. The field measurement data in Table 5-5 are the final measurements collected after well purging, and represent the closest approach to stabilized values of these parameters. The measured pH of domestic wells ranged from 5.77 to 11.65, and there is no apparent trend in pH, conductivity, or temperature across the site.

5.3.2 Analytical Results

During first round sampling domestic wells were analyzed for full priority pollutants plus forty additional peaks (tentatively identified compounds). During second round sampling wells were analyzed for priority pollutant volatile organics plus fifteen additional peaks. Analytical results are presented in Appendices F and G.

The principal priority pollutant organic compound found in domestic wells is TCE, and concentrations ranged from below detection to 340 ug/l. A total of 17 out of 35 wells sampled ~~was~~ were found to contain more than 5 ug/l TCE (the contract required detection limit). Four wells contained concentrations of TCE estimated to be less than 5 ug/l. Three of these four wells were resampled during second round sampling and the presence of TCE was confirmed using lower detection limits. One of the two private wells sampled in Rocky Hill contained 110 ug/l TCE. Although TCE concentrations in these recent rounds of analyses are not identical to the previous results, they are generally within a factor of two to three. The areas of highest TCE contamination found in earlier investigations (the end of Oxford Circle, near the end of Robin Drive, and Cleveland Circle) are approximately the same as in this study. Table 5-9 lists those residences which are not currently connected to public water and corresponding analytical results from this and previous studies.

Other priority pollutant organic compounds detected repeatedly in domestic wells include: 1,1 dichloroethane, tetrachloroethene, trans-1,2-dichloroethene, 1,1,1 trichloroethane, methylene chloride, acetone, total phenols. Of these compounds, methylene chloride and acetone, were also detected in the field or trip blanks. Tentatively identified compounds in domestic well samples are included in Appendix F. The only tentatively identified compound found in more than one domestic well is 1,1,2-trichloro-1,2,2-trifluoroethane. This compound occurred in five wells in estimated concentrations ranging from 3 to 12 ug/l.

Both TCE and tetrachloroethene occurred repeatedly in concentrations well above the site-specific applicable or relevant and appropriate requirements (ARARS) of 1 ug/l for each of these compounds. Chlordane occurred in one well at a concentration of 0.76 ug/l which is slightly above the 0.5 ug/l ARAR for this compound. Because chlordane occurred only once it is not considered to be related to the site contamination.

Priority pollutant metals were detected in a number of the domestic wells. Wells in which these metals exceeded NPDWR MCLs are shown in Table 5-10. Exceedances of NSDWR MCLs are also included on this table. Exceedances of these standards were found for lead (three wells), chromium (one well), silver (one well), iron (three wells) and manganese (four wells). There is no apparent relationship between organic contamination and priority pollutant metals exceedance. The wells also do not appear to have any explainable relationship with each other with respect to the metals concentrations.

5.4 CHEMICAL SOIL INVESTIGATION

5.4.1 In-Situ Measurements

During sample collection split spoon soil samples and boreholes were scanned in the field for the presence of volatile organic compounds using an photoionization detector (HNU). Results of these scans are listed on individual boring logs in Appendix C. Only one of the borings (SB-3) produced samples containing measurable concentrations of organic vapors. Borehole headspace readings from 2 ft to 8 ft below the ground surface measured 10 ppm (parts per million). Split spoons collected from 2 through 10 ft below ground surface produced readings of 1 to 10 ppm with ambient air producing readings of 0.2 ppm.

5.4.2 Analytical Results

Nearly all of the soil samples, field, trip and laboratory blanks contained substantial amounts (>10 ug/kg) of methylene chloride and acetone (Appendix B). The presence of these compounds in the blanks suggests that they are artifacts resulting from laboratory procedures and/or field decontamination procedures. Of the other compounds found only five were detected above detection limits: chloroform, bis (2-ethylhexyl) phthalate, PCB-1248, total phenols and total xylenes. Chloroform was present in SB-1 between 14 and 16 ft at a concentration of 7.3 ug/kg. All of the other compounds listed above were detected in SB-3 from 2 to 4 and from 6 to 8 ft below ground surface. No TCE was detected in any of the soil samples.

High estimated concentrations (>150 ug/l) of tentatively identified compounds were found in soil borings SB-2,SB-3, SB-12 and SB-15. Soil boring SB-3 contained very high concentrations (from 9800 to 350000 ug/l) of 18 tentatively identified compounds. Most of the tentatively identified compounds are alkanes and aromatic hydrocarbons. One notable exception is the molecular sulfur reported in SB-12.

Priority pollutant metals were detected in all of the soil samples analyzed for inorganic compounds. As compared to NJDEP action levels for surface soils, only one soil sample was in exceedence. Boring SB- 5 contained arsenic and copper at concentrations of 22 and 1120 mg/kg respectively. NJDEP identifies concentrations of 20 and 170 mg/kg, respectively, for these metals to be of concern.

5.5 STREAM SEDIMENT INVESTIGATION

5.5.1 Analytical Results

Methylene chloride and acetone were detected in all of the sediment samples collected. In each instance these compounds were also detected in laboratory blanks and are therefore suspected to be laboratory artifacts. The only other compounds detected were in the sample collected at stream location SW-4 (Plate 3-1). This sample contained toluene (at a level below detection limits) and 2-butanone (19 ug/kg).

No tentatively identified compounds were found in these samples.

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5.6 SURFACE WATER INVESTIGATION

5.6.1 In-situ Measurements

In-situ measurements of stream water samples are listed in Table 5-10. Measurements of pH ranged from 6.61 to 9.93 standard units. Temperatures ranged from 17.5 to 20.0 degrees Centigrade. Conductivities ranged from 133 to 157 umhos. There are no apparent correlations between the three parameters measured; nor are there apparent distinctions between samples from the Millstone River and the sample from its tributary.

5.6.2 Analytical Results

The only organic compounds detected in stream water samples were methylene chloride and acetone. These compounds were also found in laboratory blanks and are therefore suspected to be laboratory artifacts.

Priority pollutant metals were detected in all of the stream water samples. None of the metals were exceedence of NJPDES Surface Water Quality Criteria (May, 1985).

No tentatively identified compounds were found in these samples.

5.7 SEPTIC TANK INVESTIGATION

5.7.1 In-situ Measurements

Measurements made in the field during septic tank sampling are listed in Table 5-12. Temperatures were mostly between 23 and 26 degrees Centigrade with one exception, Tank #2, measuring 34 degrees. Measurements of pH ranged from 6.27 to 7.37 standard units. Conductivities ranged from 90 to 2000 umhos. Tank No. 3 had both the highest pH and the highest conductivity. Other correlations between parameters are not apparent. Similarly, there are no apparent trends in these parameters across the site (Plate 3-1).

5.7.2 Analytical Results

Six of the seven septic tanks sampled contained volatile organic compounds at levels above detection limits. These include chloroform, ethylbenzene, methylene chloride, toluene, acetone, and 2-butanone. Three of the tanks contained total volatile concentrations of over 1,000 ug/l.

Of the six tentativley identified compounds detected in septic tank samples only two occurred repeatedly: thiobis-methane and methanethiol.

5.8 AIR QUALITY INVESTIGATION

Results of the ambient air survey are listed in Table 5-13. The survey did not identify any sources or pathways of contaminants at the location of the 13 PRPs on site. No additional potential sources were observed during the survey (i.e., road spills).

TABLE 5-1
GROUND WATER ELEVATIONS AND MONITORING WELL DATA

Monitoring Well	Elev. of Outer Casing (ft)	Elev. of Inner Casing (ft)	Approx. Height of Riser (ft)	Ground Elev. (ft)	Total Depth of Well (ft)	11 July 1986 Depth to Water * TOC (ft)	11 July 1986 Ground Water Elev. (ft)	3 Nov 1986 Depth to Water * TOC (ft)	3 Nov 1986 Ground Water Elev. (ft)	13 Dec 1986 Depth to Water * TOC (ft)	13 Dec 1986 Ground Water Elev. (ft)	21 Aug 1987 Depth to Water TOC (ft)	21 Aug 1987 Ground Water Elev. (ft)
MW-1S	101.97	100.60	1.10	99.5	19.5	17.93	82.67	20.38	80.22	8.69	91.91	10.45	90.15
MW-1D	101.93	101.45	1.95	99.5	150.0	38.52	62.93	38.93	62.52	35.44	66.01	37.58	63.87
MW-2S	61.19	61.09	-0.31	61.4	21.0			14.09	47.00	11.09	50.00	13.22	47.87
MW-2D	61.64	61.34	-0.06	61.4	150.0			22.32	39.02	18.70	42.64	21.6	39.74
MW-3S	142.71	142.64	0.84	141.8	64.5	50.78	91.86	53.71	88.93	47.38	95.26	48.91	93.73
MW-3D	143.42	143.02	1.22	141.8	98.0	50.97	92.05	54.86	88.16	48.19	94.83	49.3	93.72
MW-4S	124.24	123.43	0.63	122.8	19.5			dry		dry		dry	
MW-4D	123.14	122.91	0.11	122.8	150.0			21.93	100.98	20.09	102.82	21.6	101.31
MW-5S	142.76	141.73	0.13	141.6	36.0			dry		dry		dry	
MW-5D	142.26	142.07	0.47	141.6	150.0			49.71	92.36	40.55	101.52	44.67	97.4
MW-6S	147.24	146.94	1.04	145.9	40.0			39.59	107.35	36.02	110.92	36.85	110.09
MW-6D	148.17	147.74	1.84	145.9	100.0			41.96	105.78	37.86	109.88	38.41	109.33
MW-7S	146.04	145.26	1.46	143.8	41.5	35.07	110.19	37.64	107.62	31.36	113.90	32.07	113.19
MW-7D	145.50	145.26	1.46	143.8	150.0	38.46	106.80	43.41	101.85	34.87	110.39	36.14	109.12
MW-9S	151.63	150.29	0.49	149.8	46.5	41.48	110.15	48.37	103.26	43.36	108.27	38.81	111.48
MW-9D	151.96	151.88	2.08	149.8	250.0	76.09	75.79	88.96	62.92	46.54	105.34	67.1	84.78
MW-10S	154.41	153.50	1.80	151.7	46.5	43.39	111.02	dry		44.86	109.55	38.46	115.04
MW-10D	153.02	152.75	1.05	151.7	250.0	71.81	80.94	no meas.		46.66	106.09	56.08	96.67
MW-11S	130.35	129.98	1.98	128.0	25.0			dry		18.10	111.88	23.67	106.31
MW-11D	129.81	128.84	0.84	128.0	250.0			47.57	82.24	23.18	106.63	25.92	102.92
MW-13S	113.37	111.81	1.21	110.6	20.0	21.28	92.09	21.62	91.75	9.47	103.90	12.31	99.5
MW-13D	112.42	112.13	1.53	110.6	250.0	26.83	85.30	33.46	78.67	17.46	94.67	23.32	88.81
MW-14S	75.82	74.71	1.61	73.1	19.0			15.55	60.27	4.85	70.97	14.05	60.66
MW-14D	74.63	73.73	0.63	73.1	150.0			13.83	59.90	12.76	60.97		
MW-15S	126.25	125.50	1.60	123.9	25.5	26.56	98.94	dry		16.04	109.46	20.3	105.20
MW-15D	125.20	124.88	0.98	123.9	250.0	27.53	97.35	41.02	83.86	19.22	105.66	22.88	102.00
MW-16	125.76	125.42	-0.28	125.7	62							18.14	107.28
MW-17	141.45	141.2	1.90	139.3	82							34.70	106.50
MW-18	115.97	115.64	2.34	113.3	80							11.54	104.10
MW-19	40.61	39.29	1.09	38.2	151							4.84	35.77
RHWW	153.84									52.00	101.84		

* For wells MW-9S, MW-10S, MW-11D, MW-13S, MW-14S and MW-19 the measuring point was the outer casing. For all other wells [illegible] oint used was the inner casing.

TABLE 5-2
TRANSMISSIVITY FROM PUMPING TEST DATA

Well	Stage	Jacob Method Apparent Transmissivity gal/day/ft	Theis Solution(1) Apparent Transmissivity gal/day/ft
MW-9D	Drawdown	7.3×10^3	6.4×10^3
MW-9D	Recovery	8.1×10^3	7.3×10^3
MW-10D	Drawdown	8.5×10^3	7.5×10^3
MW-10D	Recovery	9.4×10^3	7.8×10^3
Pumping Well	Drawdown	8.9×10^3	—
Pumping Well	Recovery	8.1×10^3	7.1×10^3

(1) See Table H-1 for curve match data.

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TABLE 5-3

TRANSMISSIVITY FROM PUMP TEST-DATA

BY JENKINS-PRENTICE METHOD

Well	Stage	Apparent Transmissivity gal/day/ft
MW-7D	Drawdown	3.3×10^3
MW-11D	Drawdown	6.4×10^3
MW-15D	Drawdown	4.4×10^3

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TABLE 5-4
SLUG TEST RESULTS

Well Number	Hydraulic Conductivity 1* (ft/sec)	Hydraulic Conductivity 2** (ft/sec)
MW-2D	2.3×10^{-7}	3.8×10^{-6}
MW-3S	1.2×10^{-6}	N/A
MW-4D	2.6×10^{-6}	1.5×10^{-5}
MW-6D	5.2×10^{-6}	2.5×10^{-5}
MW-7S	1.3×10^{-5}	N/A
MW-7D	9.9×10^{-6}	1.4×10^{-5}
MW-13D	8.4×10^{-7}	4.5×10^{-6}
MW-14D	2.5×10^{-6}	4.3×10^{-6}
MW-15D	6.4×10^{-7}	3.8×10^{-6}

* Conductivity 1 - Using method of Theis (1935) for deep wells and method of U.S. Dept. of Navy (1974) for shallow wells

** Conductivity 2 - Using method of Bouwer and Rice (1976)

N/A Not Available

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TABLE 5-5
IN-SITU CHEMICAL MEASUREMENTS

Well	Date	pH (Std. Units)	Conductivity (umho/cm)	Temp. (°C)
Domestic Wells (1) - Block and Lot				
9/9, 1q(2)	6/6/86	6.84	275	18.0
9/8(2)	6/6/86	7.31	220	16.5
9/7+7.0q(2)	6/6/86	7.28	225	16.0
9/5(2)	6/6/86	7.28	155	16.5
9/2.04+2.4q(2)	6/6/86	7.56	225	15.0
23001 17	6/6/86	8.3		9.7
23001 20	6/6/86	8.2		12.1
23001 20	4/22/87	7.3	400	14.0
23001 23	6/6/86	11.05		9.5
23001 27	6/6/86	7.47		5.3
23001 28	6/6/86	6.90		10.5
28001 1	6/5/86	6.37	260	15
28001 66	6/6/86	6.78	225	14.5
29001 2	6/6/86	7.35		9.6
29001 4	6/6/86	11.65		9.3
29001 5A	6/6/86	8.35		9.8
29001 37	6/5/86	6.52	170	15
29002 4	6/6/86	7.58		10.0
29002 8	6/5/86	7.39		15.0
29002 11	6/5/86		220	14.5

(1) In-situ measurements of domestic wells are final readings after purging well.
(2) Franklin Township
(3) Rocky Hill

TABLE 5-5
IN-SITU CHEMICAL MEASUREMENTS

Well	Date	pH (Std. Units)	Conductivity (umho/cm)	Temp. (°C)
Domestic Wells (1) - Block and Lot				
29002 12	6/5/86	8.68	145	16.0
29002 14	6/5/86	6.75	245	15.0
29002 17	6/5/86	6.63		12.5
29002 22	6/6/86	7.44	335	16.0
29002 24	6/5/86	6.59	290	14.0
29002 28	6/5/86	6.74	105	15.5
29002 30	6/5/86	5.99	105	16.0
29002 33	6/5/86	6.71	210	14.5
29002 37	4/22/87	7.80	560	11.0
29002 37	6/5/86	7.50		12.1
29002 40	6/5/86	7.95		12.1
29002 43	6/5/86	7.82		12.0
29003 5	6/5/86	7.40		13.9
29003 5	4/22/87	6.7	500	13.5
29003 8	6/5/86	5.77		9.6
29003 12	6/5/86	7.67		11.7
29003 15	6/5/86	7.55	230	11.9
29003 18	6/6/86	7.39	180	15.5
14 3(3)	4/22/87	6.40	510	13.0
04 28(3)	4/22/87	6.50	1200	10.0

TABLE 5-6
IN-SITU CHEMICAL MEASUREMENTS - MONITORING WELL SAMPLING

Monitorig Well	Temperature (C)		pH (s.u.)		Conductivity (umhos)	
	Round One Sampling 11/18/86-12/4/86	Round Two Sampling 6/30/87-8/21/87	Round One Sampling 11/18/86-12/4/86	Round Two Sampling 6/30/87-8/21/87	Round One Sampling 11/18/86-12/4/86	Round Two Sampling 6/30/87-8/21/87
MW-1S	12.0	18.5	6.4	5.2	360	225
MW-1D	10.0	19.5	7.8	6.7	480	230
MW-2S	12.0	18.0	6.8	6.3	208	339
MW-2D	8.5	18.5	7.6	6.8	272	279
MW-3S	7.0	18.0	6.0	4.5	78	131
MW-3D	6.0	19.0	12.2	12.6	4160	1000
MW-4S	DRY	DRY	DRY	DRY	DRY	DRY
MW-4D	10.0	16.5	5.9	7.4	78	209
MW-4S Airport	11.0	--	5.0	--	57	--
MW-4D Airport	10.0	--	7.5	--	336	--
MW-5S	DRY	DRY	DRY	DRY	DRY	DRY
MW-5D	11.5	19.0	6.1	6.1	50	135
MW-5D Airport	11.0	--	7.5	--	288	--
MW-6S	DRY	*	DRY	*	DRY	*
MW-6D	5.0	18.5	6.9	6.0	65	70
MW-7S	9.0	19.0	5.2	4.8	460	119
MW-7D	9.0	21.0	5.5	5.4	460	138
MW-9S	DRY	18.0	DRY	6.8	DRY	139
MW-9D	8.0	16.5	6.5	6.4	200	118
MW-10S	DRY	--	DRY	4.9	DRY	80
MW-10D	11.0	18.0	7.2	6.3	78	99
MW-11S	9.0	19.5	5.6	4.2	104	95
MW-11D	10.0	19.0	6.9	6.2	148	151
MW-13S	11.0	23.0	6.5	6.9	80	253
MW-13D	10.0	19.0	6.8	7.2	48	180
MW-14S	9.0	20.0	5.6	6.6	184	240
MW-14D	10.5	18.0	6.4	7.5	168	194
MW-15S	DRY	19.0	DRY	6.6	DRY	133
MW-15D	11.0	18.0	7.5	7.8	160	288
MW-16	--	20.0	--	6.7	--	288
MW-17	--	20.5	--	5.8	--	139
MW-18	--	20.0	--	7.3	--	225
MW-19	--	18.0	--	11.0	--	350
1377-P	--	18.5	--	6.0	--	150
Village Shopper	--	--	--	6.7	--	1600

TABLE 5-7
TCE CONTENTS OF MONITORING WELLS

Well	TCE Concentration 11/18/86-11/21/86, 12/3/86-12/4/86 (ug/l)	7/1/87-7/15/87,8/21/87 (ug/l)
MW-1D	ND	ND
MW-1S	ND	ND
MW-2D	34	24
MW-2S	ND	ND
MW-3D	ND	160
MW-3D dup.	13	--
MW-3S	320	85
MW-4D	240	590
MW-4D dup.	--	630
MW-4D airport	ND	--
MW-4S airport	ND	--
MW-5D	ND	ND
MW-5D airport	ND	--
MW-6D	ND	ND
MW-7D	650	180
MW-7D (dup.)	--	180
MW-7S	650	160
MW-9D	6.3	3.7 J
MW-9D dup.	6.3	--
MW-9S	--	6
MW-10D	ND	ND
MW-10S	--	ND
MW-11D	ND	2.7 J
MW-11S	ND	ND
MW-13D	ND	ND
MW-13S	ND	ND
MW-14D	ND	ND
MW-14S	ND	ND
MW-15D	ND	ND
MW-16	--	ND
MW-17	--	300
MW-18	--	2.3 J
MW-19	--	ND
Village Shopper	--	3.1 J
1377-P	--	150

ND: Not Detected at detection limit of 5 ug/l.
J: Indicates an estimated value.
--: Not sampled.

TABLE 5-8

PRIORITY POLLUTANT METALS IN MONITORING WELLS

IN EXCEEDANCE OF NPDWR AND NSDWR

	NPDWR(1) (MCL)	MW-3D	MW-3D (dupl.)	MW-3S	MW-5D
Arsenic	50		186		
Barium	1,000	1,660	2,300		
Cadmium	10				
Chromium	50	304	406	90	60
Lead	50	686	786		
Mercury	2				
Selenium	10				
Silver	50				

	NSDWR(2) (MCL)	Monitoring Wells in Exceedance of MCL
Iron	300	all except MW-7D, MW-14S
Manganese	50	all except MW-7D, MW-10D, MW-11D, MW-13S, MW-14S, MW-15D
Zinc	5,000	none

All concentrations in ug/l.

(1) National Primary Drinking Water Regulations, Maximum Contaminant Levels, 40 CFR 141. Equivalent to NJ Maximum Concentration of Constituents for Ground Water Protection, NJAC 7:14A-126.6

(2) National Secondary Drinking Water Regulations, Maximum Contaminant Levels, 40 CFR 143

TABLE 5-9
MONTGOMERY RESIDENTS NOT CONNECTED TO
PUBLIC WATER AS OF May 1987

Block	Lot	TCE Concentration ug/l June 1986	April 1987	TCE Concentration ug/l Average 1979-1987
23001	20	1.9	1.4	1.7
23001	27	60		73
23001	28	140		85
29002	1			1.6
29002	3			
29002	4	58		58
29002	5			ND
29002	6			
29002	7			9.9
29002	8	18		18
29002	12	64		35
29002	13			39
29002	14	72		23
29002	15			ND
29002	16			ND
29002	17	3.9		3.9
29002	18			
29002	19			
29002	24	46		29
29002	28	ND		237
29002	37	2.5	14.6/14.4(duplicates)	12.1
29002	40	40/44 (duplicates)		41
29002	43	35		31

TABLE 5-9 (Continued)
MONTGOMERY TOWNSHIP RESIDENTS NOT CONNECTED TO
PUBLIC WATER AS OF 7 MAY 1987

Block	Lot	TCE Concentration ug/l June 1986	TCE Concentration ug/l April 1987	TCE Concentration ug/l Average 1979-1987
29003	2			
29003	3			
29003	4			
29003	5	3.8	3.6	3.7
29003	6			
29003	7			
29003	8	ND		6.7
29003	10			
29003	11			
29003	12	32		13
29003	13			
29003	18	ND		ND
29001	2	ND		ND
29001	3	ND		
29001	5A	ND		ND
29001	6A	ND		

1BM-133TB

TABLE 5-10
PRIORITY POLLUTANT METALS IN DOMESTIC WELLS
IN EXCEEDANCE OF NPDWR AND NSDWR

	NPDWR[1] (MCL)	NSDWR[2] (MCL)	DOMESTIC WELL - BLOCK AND LOT 9 5	29001 2	29001 4	29002 22	29002 24	29002 30	29002 33	29002 18	29003 40	29002 43
Arsenic	50											
Barium	1,000											
Cadmium	10											
Chromium	50									117		
Lead	50						143	2,170				740
Mercury	2											
Selenium	10											
Silver	50		180									
Iron		300			3,840				656		510/514[3]	
Manganese		50		295	222	94	74					
Zinc		5,000										

All concentrations in ug/l

1. National Primary Drinking Water Regulations, Maximum Contaminant Levels, 40 CFR 141. Equivalent to NJ Maximum Concentration of Constituents for Ground Water Protection NJAC 7:14A-126.6
2. National Secondary Drinking Water Regulations, Maximum contaminant Levels, 40 CFR 143.
3. Duplicate Samples.

IBM-133TG

TABLE 5-11
IN SITU CHEMICAL MEASUREMENTS
STREAM WATER

Location	pH (S.U.)	Temp. (°C)	Cond. (mmhos)
SW-1	7.90	17.5	135
SW-2	9.93	18	149
SW-3	8.36	18	133
SW-4	6.93	19	156
SW-5	6.61	20	157

IBM-133Tx

TABLE 5-12
IN SITU CHEMICAL MEASUREMENTS
SEPTIC TANKS

Location	pH (S.U.)	Temp. (°C)	Cond. (mmhos)
Tank No. 1 P.G.T.	7.16	26°	1300
Tank No. 2 Friendly's	6.30	34	710
Tank No. 3 William Penn	7.37	23	2000
Tank No. 4 1501 Route 206	6.92	26	390
Tank No. 5 Print Shop	6.50	24	1150
Tank No. 6 1377 Route 206	6.54	23	630
Tank No. 7 Village Shopper	6.27	24	90

IBM-1331y

TABLE 5-13
AIR QUALITY INVESTIGATION DATA

Date:	14 April 1987
Detector:	HNU Systems, Inc. Photo-ionizer Model PI-101
WCC Serial #:	000074
Lamp:	10.2 ev
Calibration:	HNU Calibration Gas (benzene) 14 April 1987 8:00
Weather:	Sunny, 60°s, mild breeze

Sampling Site	HNU Reading (ppm) Site	HNU Reading (ppm) Background
Princeton Airport:		
storm sewer drain main parking lot	0.2	0.2
brook east of main lot (flowing south)	0.2	0.2
storm sewer drains along road to main		
lot #1	0.2	0.2
lot #2	0.2	0.2
lot #3	0.2	0.2
Princeton Volkswagon:		
area around diesel and unleaded gas pumps	0.2	0.2
underground fuel tank covers	0.2	0.2
storm sewer drains in parking lot #1	0.2	0.2
lot #2	0.2	0.2
lot #3	0.1	0.1
lot #4	0.2	0.2
roof gutter drainage pipe running under front lawn	0.2	0.2
Wm Penn Gas Station:		
septic tank field (recently disturbed soil)	0.4	0.2
vent pipes back of garage	0.2	0.2
storm sewer drains in parking lot #1	0.2	0.2
lot #2	0.2	0.2
waste engine oil tank	0.2	0.2
oil, grease deposit on south side of building	0.4	0.2
Town and Country Animal Hospital:		
parking lot	0.2	0.2

TABLE 5-13
AIR QUALITY INVESTIGATION DATA - continued

Sampling Site	HNU Reading (ppm) Site	Background
Compo Industries:		
storm sewer drains in parking lot #1	0.2	0.2
lot #2	0.2	0.2
lot #3	0.1	0.1
lot #4	0.2	0.2
lot #5	0.1	0.1
lot #6	0.1	0.1
standing water in parking lot east of main building	0.2	0.2
material handling and storage area south of main building	0.2	0.2
abandoned sewage treatment facility-east of parking lot	0.2	0.2
Princeton Gamma Tech:		
vents aerobic treatment tank	0.2	0.2
soil around treatment tank	0.2	0.2
area around gas pump	0.2	0.2
storm sewer drain near gas pump	0.4	0.2
storm sewer drains in parking lot #1	0.2	0.2
lot #2	0.2	0.2
lot #3	0.2	0.1

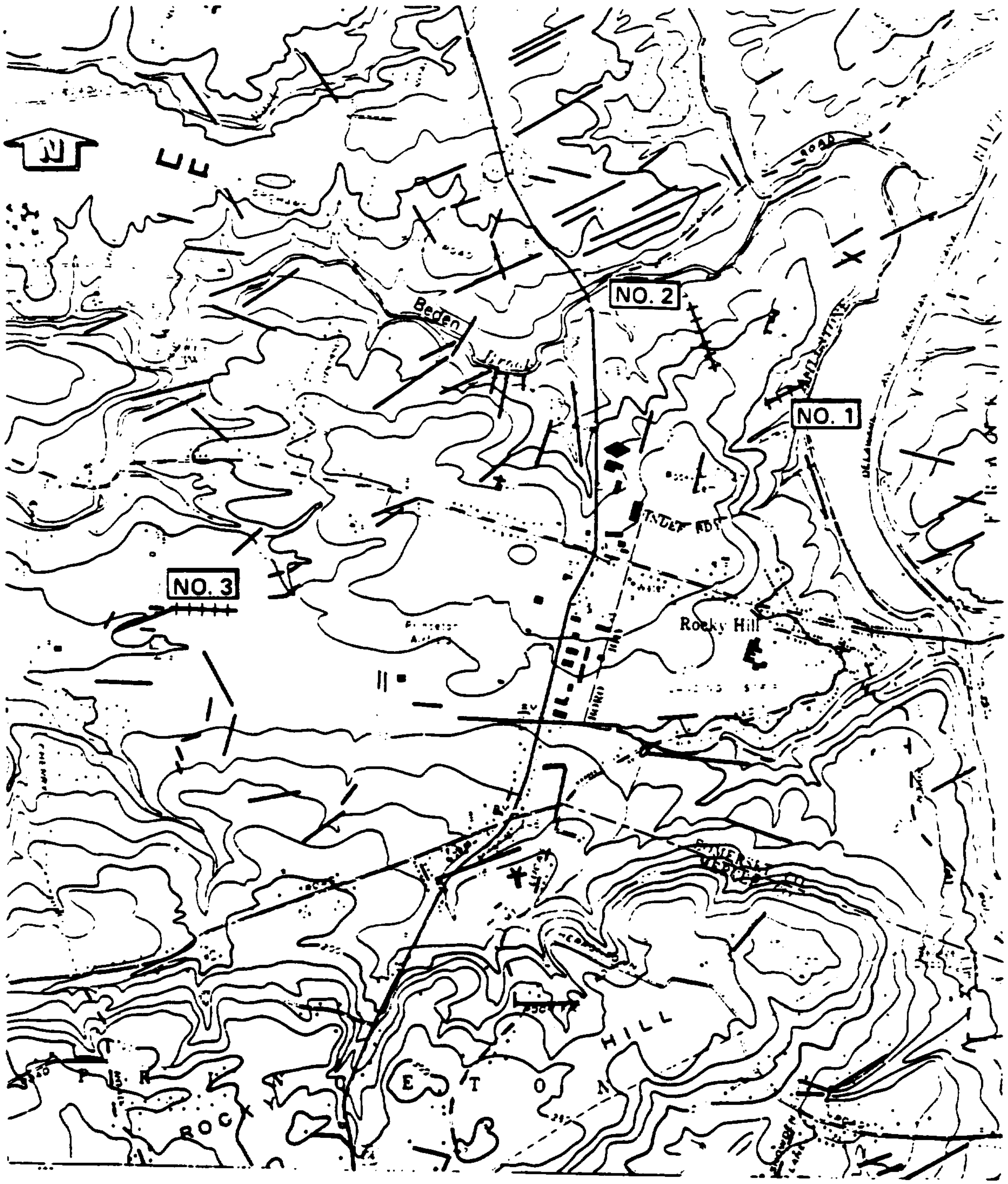
TABLE 5-13
AIR QUALITY INVESTIGATION DATA - continued

Date: 21 April 1987
Detector: HNU Systems, Inc. Photo-ionizer Model PI-101
WCC Serial #: 000074
Lamp: 10.2 ev
Calibration: HNU Calibration Gas (benzene) 21 April 1987 8:50
Weather: Overcast to partial sun, 60°s, mild breeze

Sampling Site	HNU Reading (ppm) Site	Background
Thul's Mobil Gas Station:		
disturbed soil around septic tank and laterals	0.2	0.2
storm sewer drains in parking lot #1	0.2	0.2
lot #2	0.2	0.2
lot #3	0.2	0.2
Tigers Tale Restaurant:		
storm sewer drains in parking lot #1	0.2	0.2
lot #2	0.2	0.2
lot #3	0.2	0.2
lot #4	0.2	0.2
storage area near kitchen	0.2	0.2
Village Shopper:		
storm sewer drains in parking lot #1	0.2	0.2
lot #2	0.2	0.2
septic tank covers along south of		
property #1	0.4	0.2
property #2	0.2	0.2
property #3	0.2	0.2
property #4	0.2	0.2
Montgomery Shopping Center:		
storm sewer drains in front parking lot #1	0.2	0.2
lot #2	0.2	0.2
lot #3	0.2	0.2
lot #4	0.2	0.2
lot #5	0.2	0.2
lot #6	0.2	0.2
septic tank covers on front lawn near		
Restaurant #1	0.2	0.2
Restaurant #2	0.2	0.2
Restaurant #3	0.2	0.2

TABLE 5-13
AIR QUALITY INVESTIGATION DATA - continued

Sampling Site	HNU Reading (ppm) Site	Background
Montgomery Shopping Center - continued:		
storm sewer drain in back parking lot #1	0.2	0.2
lot #2	0.2	0.2
Polycell:		
gravel pits in cement foundation #1	0.2	0.2
#2	0.2	0.2
#3	0.2	0.2
soil below loading dock platform	0.2	0.2
1377 Rt. 206:		
storm sewer drains in parking lot #1	0.2	0.2
lot #2	0.2	0.2
lot #3	0.2	0.2
asphalt below loading dock	0.2	0.2
soil around storage area along east wall of building	0.2	0.2
Ingersoll Rand:		
storm sewer drains in driveway and parking lot #1	0.2	0.2
lot #2	0.2	0.2
lot #3	0.2	0.2
lot #4	0.2	0.2
disturbed soil pile on north side of building	0.2	0.2
asphalt around loading dock area	0.2	0.2



0 2500 5000 FT

SCALE

LEGEND

—— LINEAMENTS INDICATED BY AERIAL PHOTOS

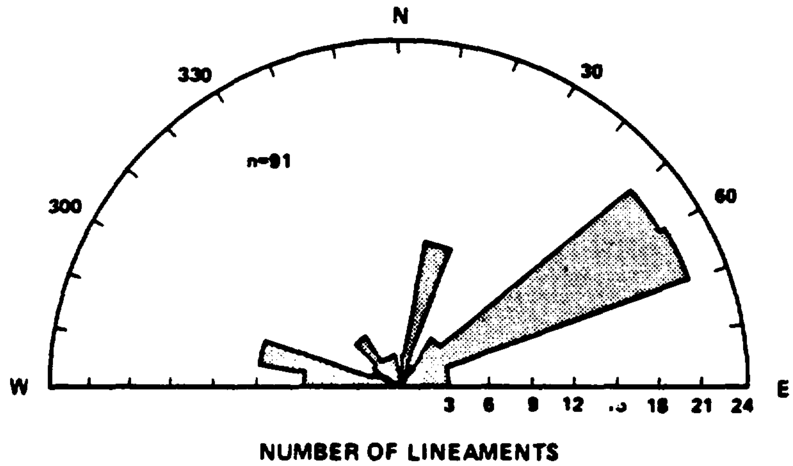
+++ LINEAMENT INVESTIGATED BY GEOPHYSICAL SURVEY

◆ FRACTURE OR FRACTURED ZONE DETECTED BY GEOPHYSICAL SOUNDINGS

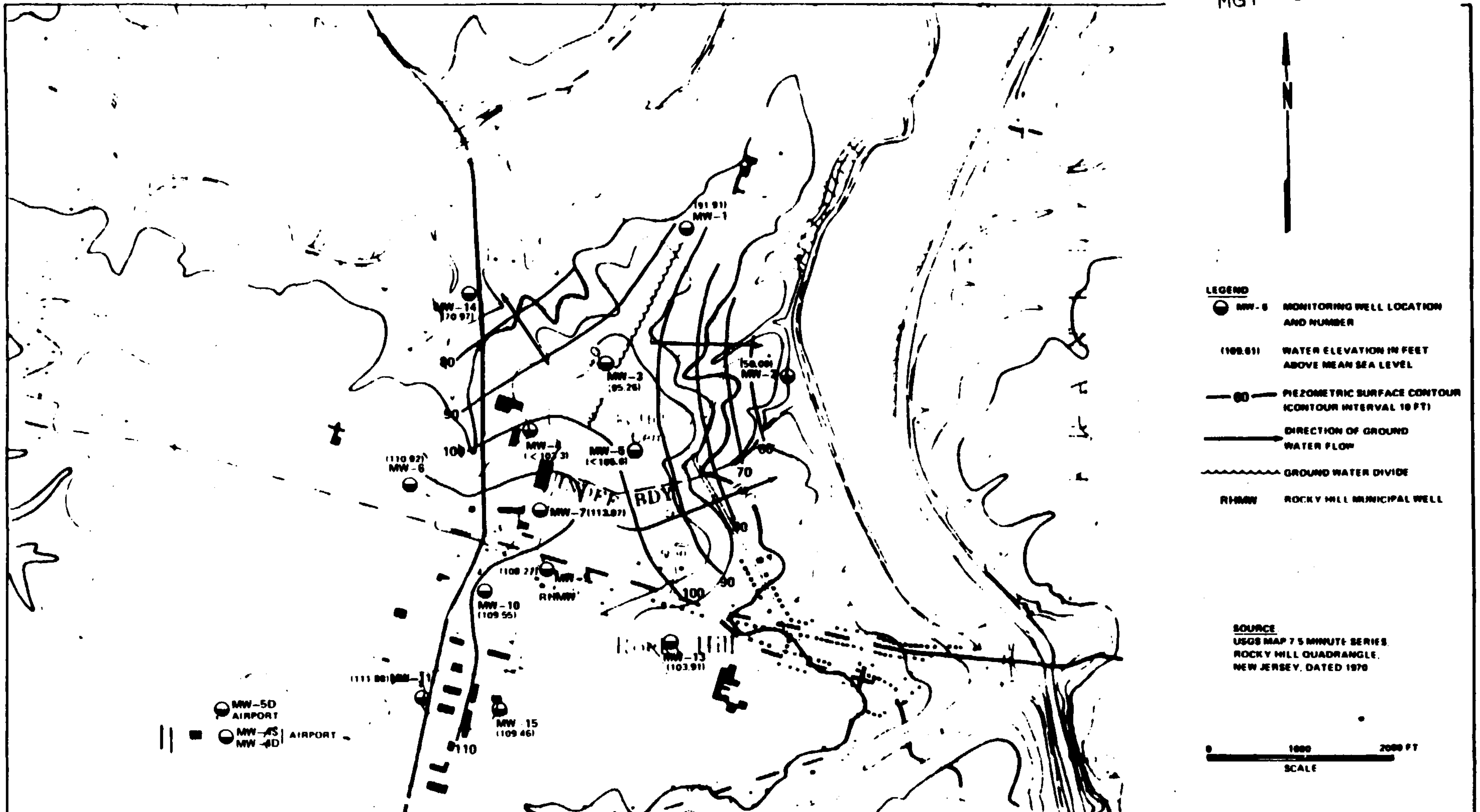
MAP SOURCE:

USGS MAP, ROCKY HILL QUADRANGLE
7.5 MINUTE SERIES (TOPOGRAPHIC)
PHOTOREVISED 1970

LOCATION OF LINEAMENTS MTHD/RHMW SITE SOMERSET COUNTY, NEW JERSEY					
WOODWARD—CLYDE CONSULTANTS CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS WAYNE, NEW JERSEY					
DR. BY:	BAS	SCALE:	AS SHOWN	PROJ.NO:	84C4007-A2M
CKD. BY:	MC	DATE:	11 DEC 1987	FIG. NO.:	5-1



ORIENTATION OF LINEAMENTS MTHD/RHMW SITE SOMERSET COUNTY, NEW JERSEY					
WOODWARD—CLYDE CONSULTANTS CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS WAYNE, NEW JERSEY					
DR. BY:	RL	SCALE: AS SHOWN		PROJ. NO84C4007A2M	
CK'D. BY:	NLB	DATE: 11 DEC 1987		FIG. NO.:	5-2

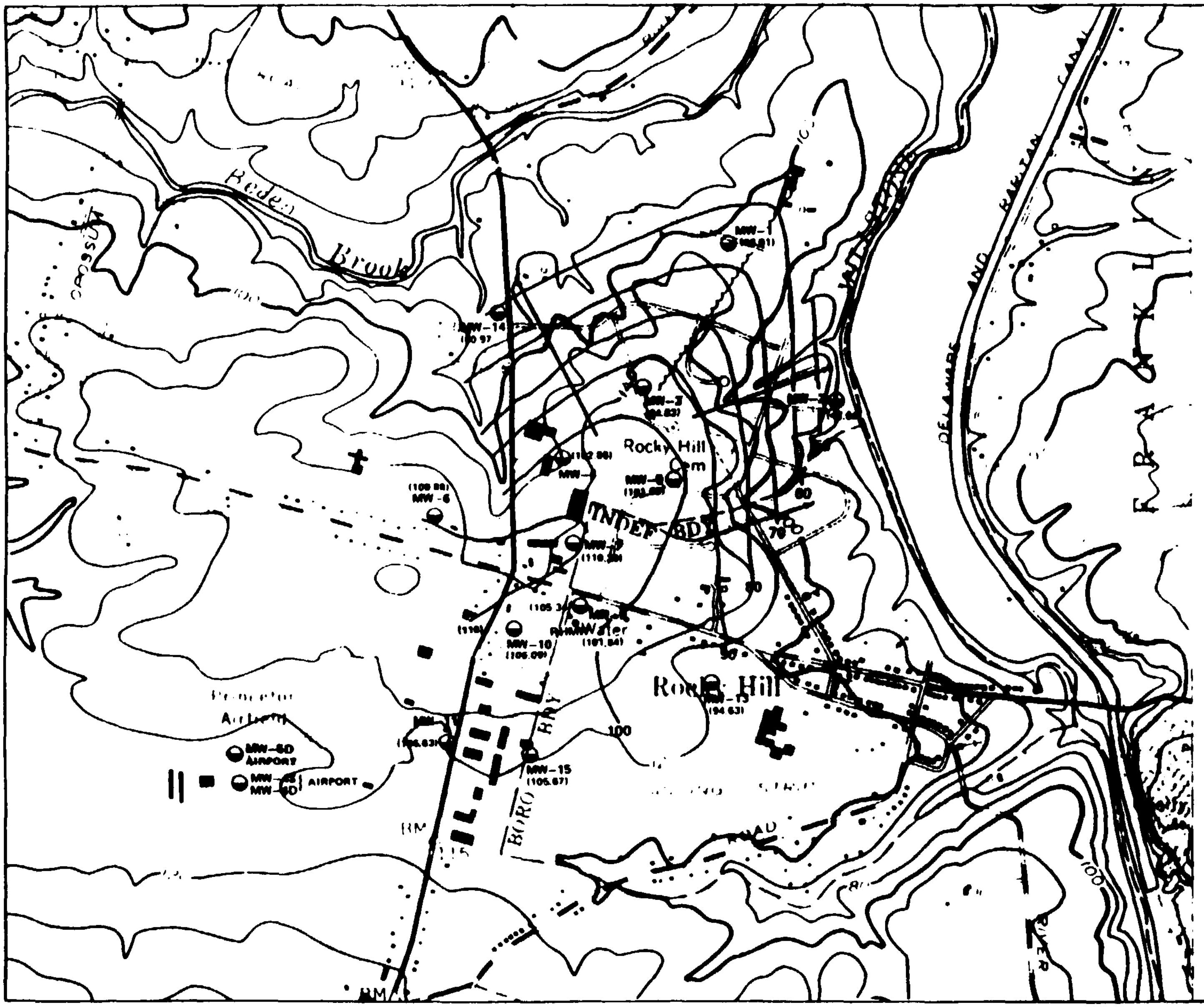


STATIC WATER ELEVATIONS IN SHALLOW WELLS
13 DECEMBER 1986

WOODWARD - CLYDE CONSULTANTS

DR BY DRS	SCALE AS SHOWN	PROJ NO 84C4007A2
CHK BY EC	DATE 11 DEC 1987	FIG NO 5-3

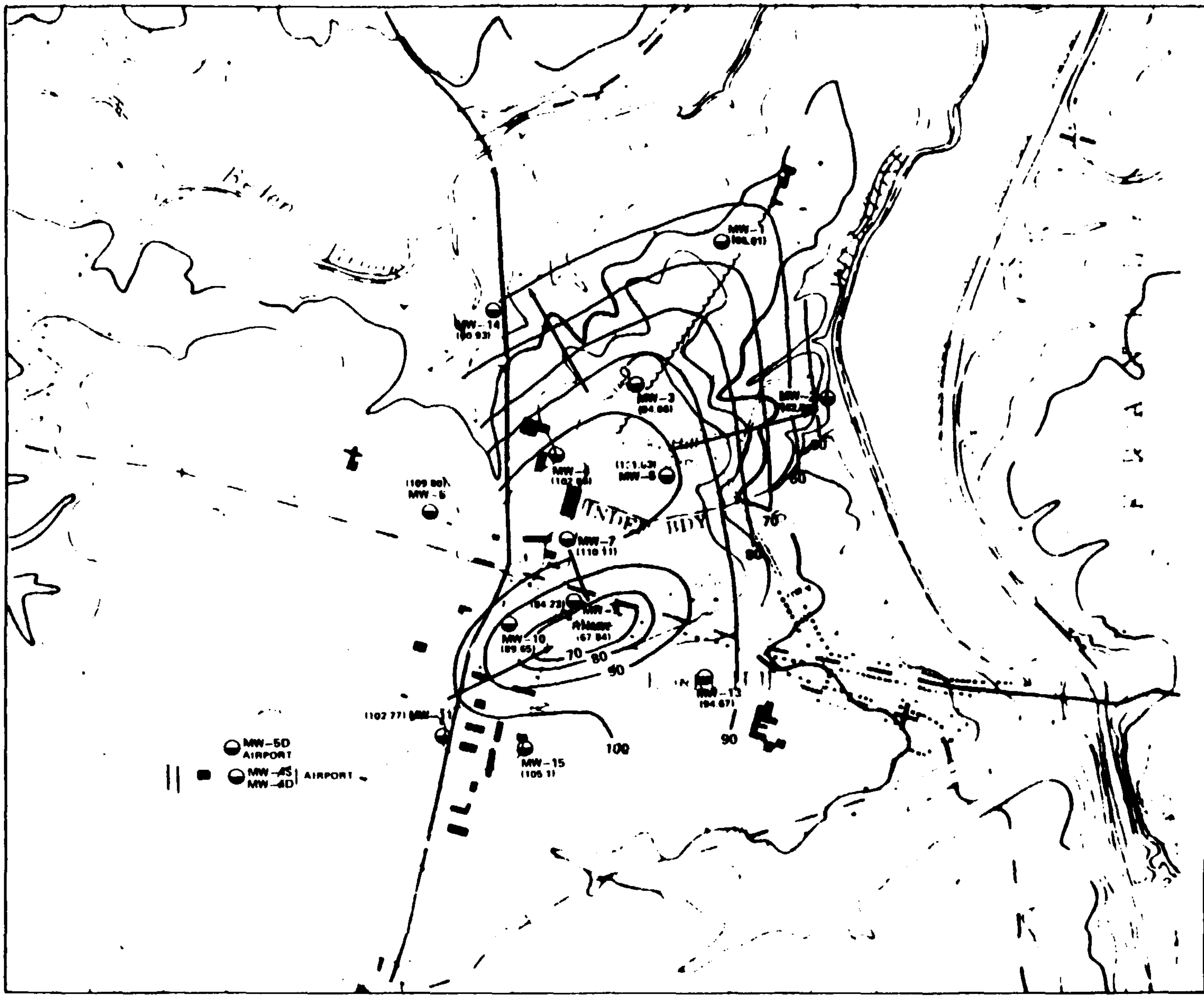
MGY 001 0116



STATIC WATER ELEVATIONS IN DEEP WELLS
13 DECEMBER 1986

WOODWARD – CLYDE CONSULTANTS

DR BY DRS | SCALE AS SHOWN | CHK'D BY EC | DATE 11 DEC 1987



LEGEND

MW-6 MONITORING WELL LOCATION AND NUMBER

(100.61) WATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL

—80— PIEZOMETRIC SURFACE CONTOUR (CONTOUR INTERVAL 10 FT)

DIRECTION OF GROUND WATER FLOW

GROUND WATER DIVIDE

RHMW ROCKY HILL MUNICIPAL WELL

SOURCE
USGS MAP 7.5 MINUTE SERIES,
ROCKY HILL QUADRANGLE,
NEW JERSEY, DATED 1970

0 1000 2000 FT
SCALE

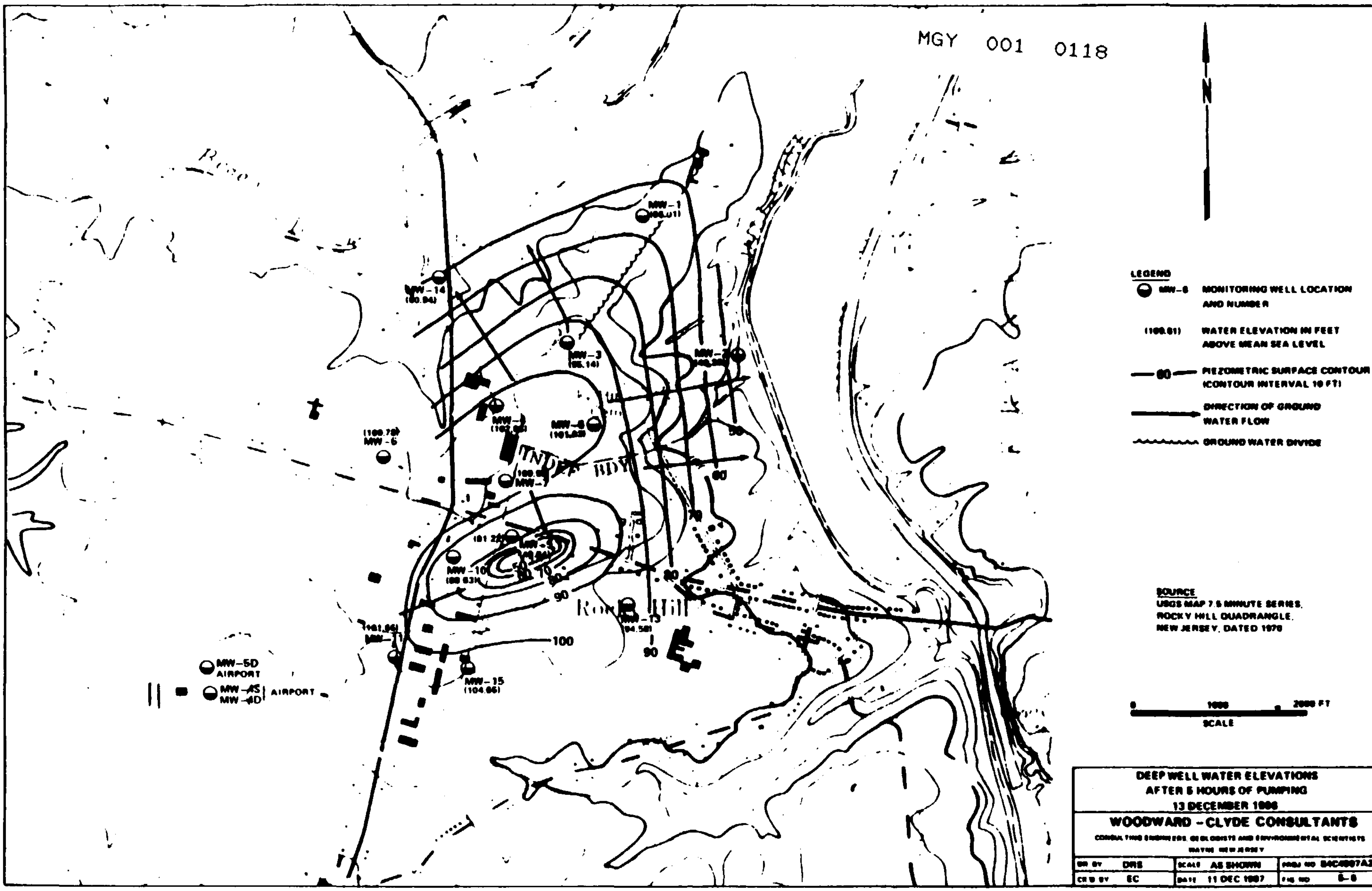
DEEP WELL WATER ELEVATIONS
AFTER 3 HOURS OF PUMPING
13 DECEMBER 1986

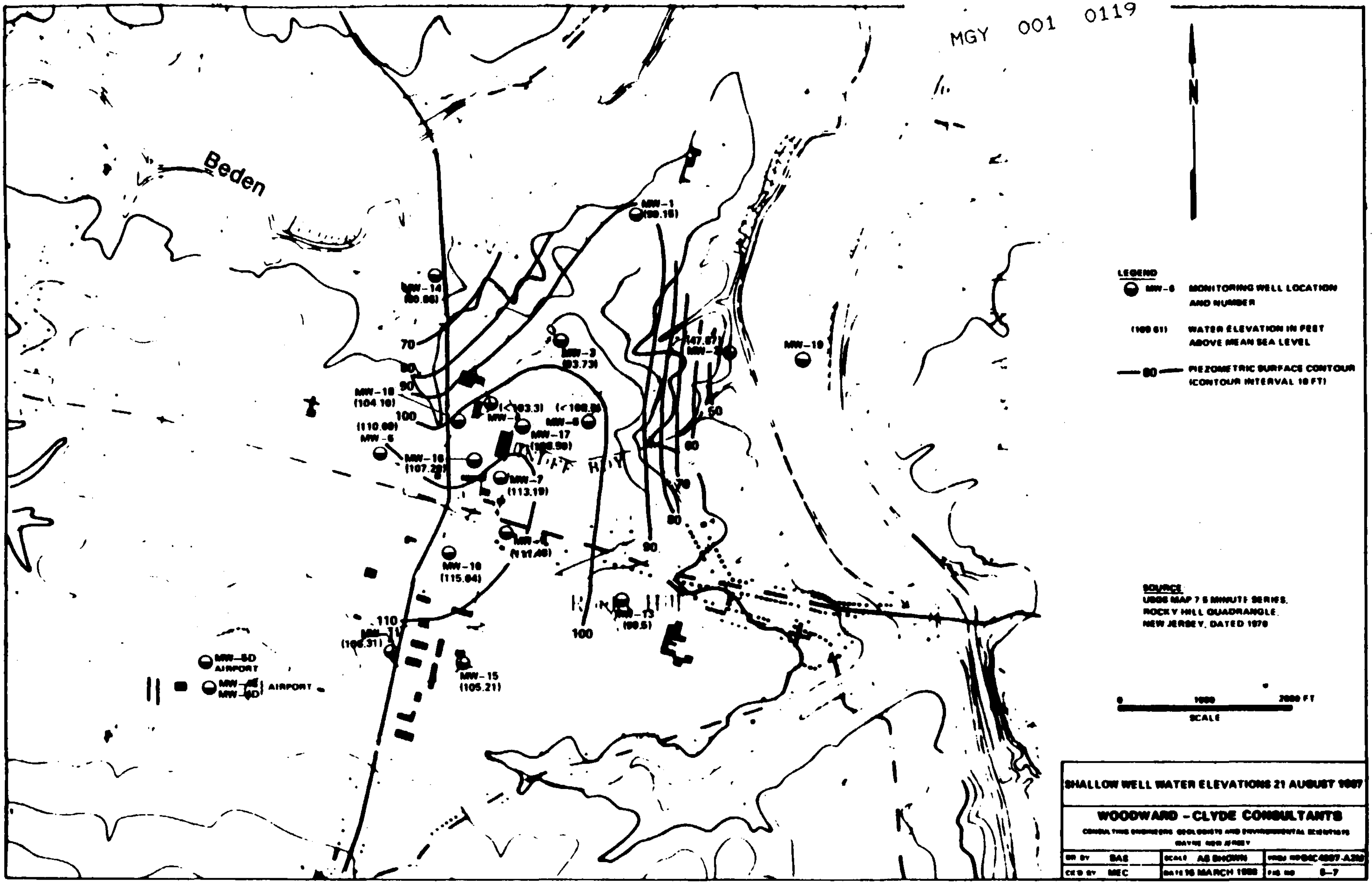
WOODWARD - CLYDE CONSULTANTS

CONSULTING ENGINEERS GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE NEW JERSEY

DR BY	DRS	SCALE	AS SHOWN	PROJ NO	86C4007A
CKD BY	EC	DATE	11 DEC 1987	FIG NO	5-6

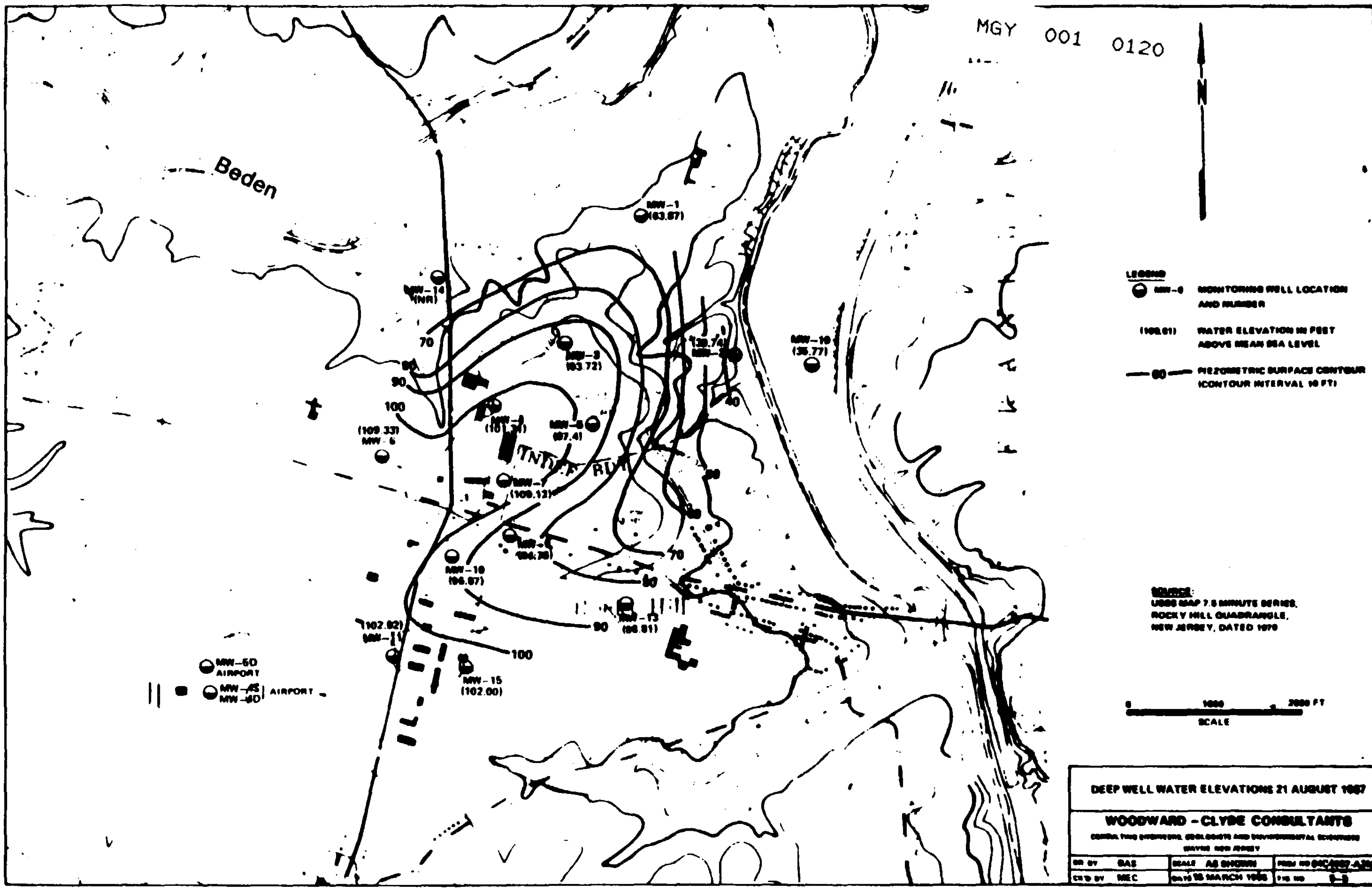
MGY 001 0118


N
LEGEND
MW-6 MONITORING WELL LOCATION AND NUMBER
WATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL
PIEZOMETRIC SURFACE CONTOUR (CONTOUR INTERVAL 10 FT)
DIRECTION OF GROUND WATER FLOW
GROUND WATER DIVIDE
SOURCE
USGS MAP 7.5 MINUTE SERIES,
ROCKY HILL QUADRANGLE,
NEW JERSEY, DATED 1970
SCALE
MW-1
MW-14
MW-3
MW-2
MW-5
MW-7
MW-10
MW-11
MW-13
MW-15
(104.86)
MW-5D
AIRPORT
AIRPORT
100
90
80
70
60
DEEP WELL WATER ELEVATIONS
AFTER 5 HOURS OF PUMPING
WOODWARD - CLYDE CONSULTANTS
SCALE AS SHOWN
EC

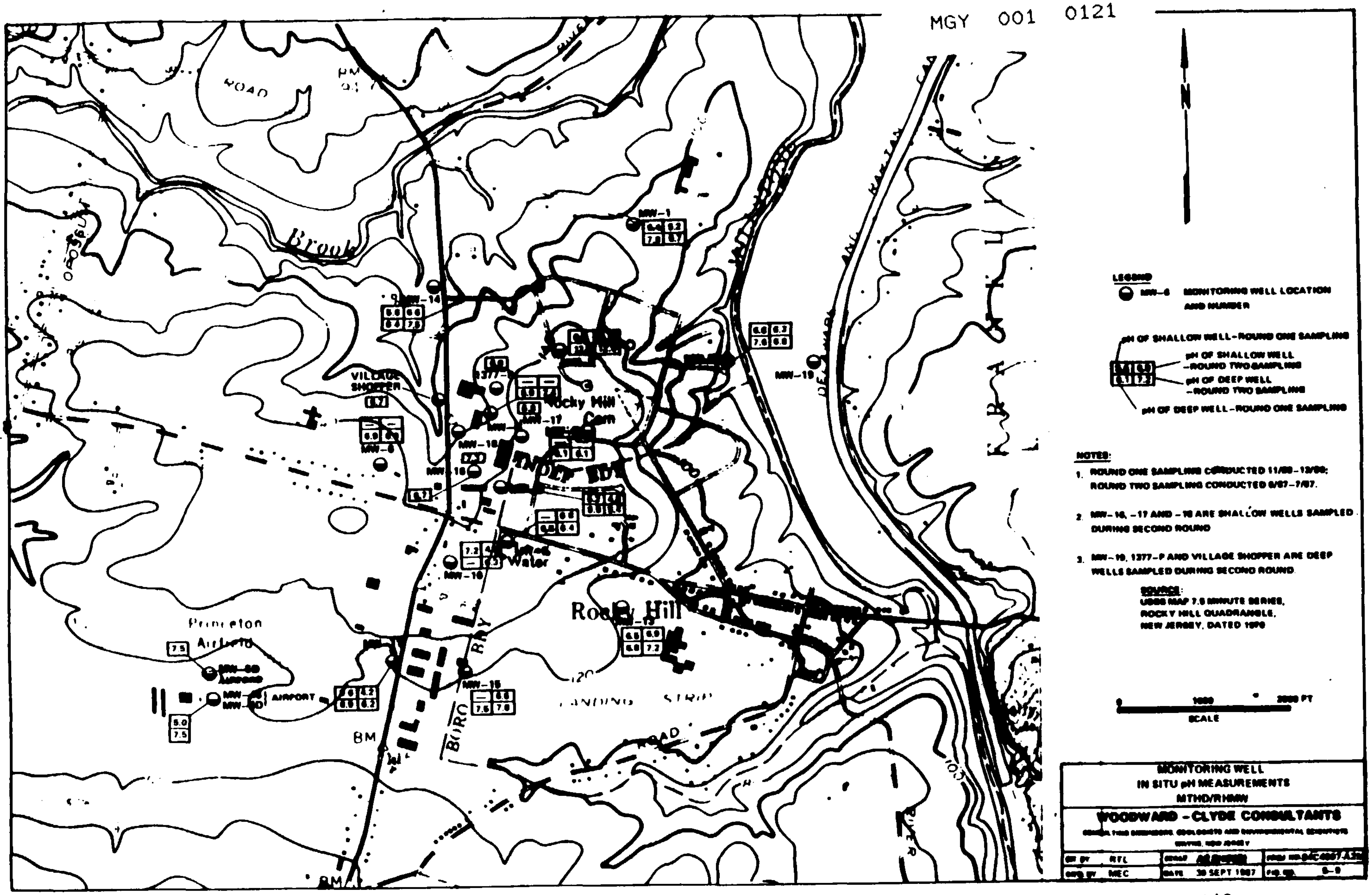


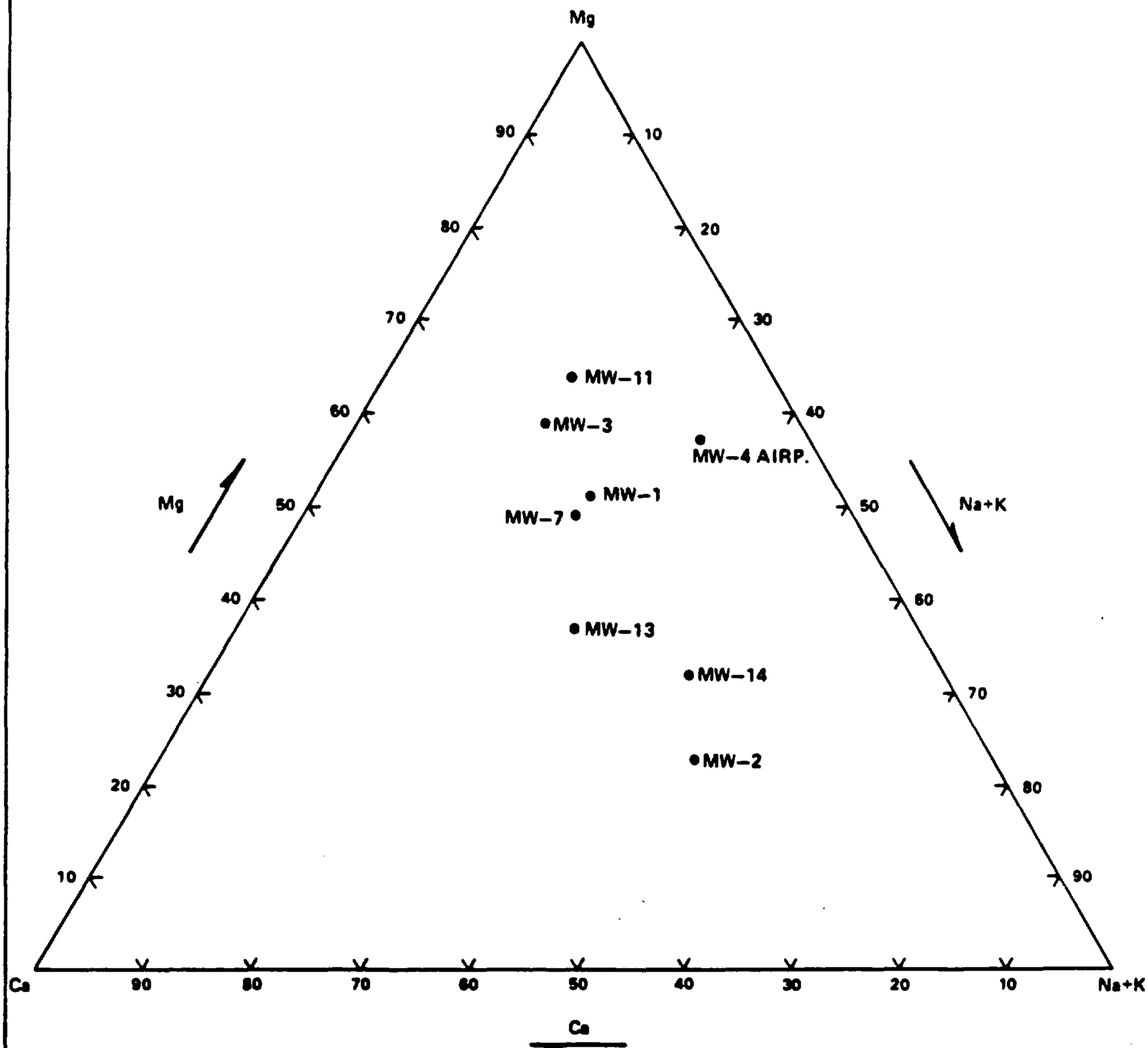
SHALLOW WELL WATER ELEVATIONS 21 AUGUST 1987

MGY 001 0120



Beden
MW-1 (63.87)
MW-14 (NR)
MW-3 (83.72)
MW-19 (35.77)
(109.33) MW-6
MW-7 (109.12)
MW-10 (96.87)
MW-15 (102.00)
MW-13 (96.81)
MW-5D AIRPORT
AIRPORT
70
80
90
100
N
LEGEND
MONITORING WELL LOCATION AND NUMBER
WATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL
PIEZOMETRIC SURFACE CONTOUR (CONTOUR INTERVAL 10 FT)
SOURCE:
USGS MAP 7.5 MINUTE SERIES, ROCKY HILL QUADRANGLE, NEW JERSEY, DATED 1970
SCALE
DEEP WELL WATER ELEVATIONS 21 AUGUST 1987
WOODWARD - CLYDE CONSULTANTS
AS SHOWN

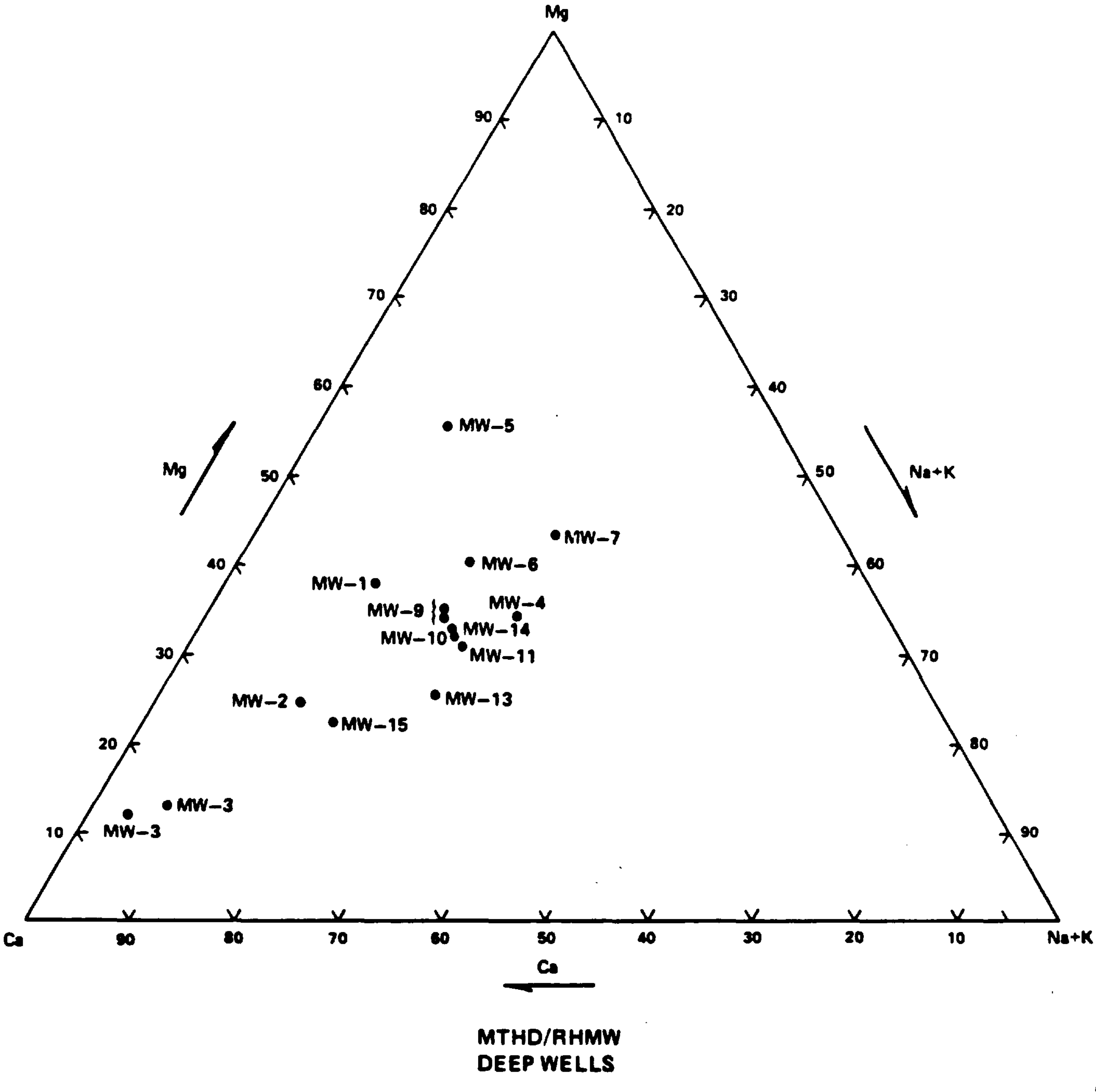

N
LEGEND
MONITORING WELL LOCATION AND NUMBER
pH OF SHALLOW WELL-ROUND ONE SAMPLING
pH OF SHALLOW WELL -ROUND TWO SAMPLING
pH OF DEEP WELL -ROUND TWO SAMPLING
pH OF DEEP WELL-ROUND ONE SAMPLING
NOTES:
1. ROUND ONE SAMPLING CONDUCTED; ROUND TWO SAMPLING CONDUCTED 6/87-7/87.
2. MW-16, -17 AND -18 ARE SHALLOW WELLS SAMPLED DURING SECOND ROUND
3. MW-19, 1377-P AND VILLAGE SHOPPER ARE DEEP WELLS SAMPLED DURING SECOND ROUND.
SOURCE:
USGS MAP 7.5 MINUTE SERIES, ROCKY HILL QUADRANGLE, NEW JERSEY
SCALE
MONITORING WELL
IN SITU pH MEASUREMENTS
MTHD/RHMW
WOODWARD - CLYDE CONSULTANTS
RTL
MEC
30 SEPT 1987
Brook
ROAD
MW-1
MW-14
MW-19
VILLAGE SHOPPER
Rocky Hill Cem
Water
Rocky Hill
Princeton Airport
AIRPORT
LANDING STRIP
MW-15
BORO
BM



MTHD/RHMW
SHALLOW WELLS

MGY 001 0122

TERNARY DIAGRAM PERCENTAGES ON BASIS OF EQUIVALENTS PER LITER					
WOODWARD - CLYDE CONSULTANTS CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS WAYNE, NEW JERSEY					
DR BY	DRS	SCALE	AS SHOWN	PROJ NO	84C4007A2M
CK'D BY	EC	DATE	11 DEC 1987	FIG NO	5-10



TERNARY DIAGRAM PERCENTAGES ON BASIS OF EQUIVALENTS PER LITER			
WOODWARD - CLYDE CONSULTANTS CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS WAYNE, NEW JERSEY			
DR BY DRS	SCALE AS SHOWN	PROJ NO 84C400.	
CK'D BY EC	DATE 11 DEC 1987	FIG NO 5-11	

MGY 001 0123

SECTION SIX
SITE CHARACTERIZATION SUMMARY

6.1 GEOLOGY

The Montgomery Township Housing Development/Rocky Hill Municipal Wellfield site is underlain by siltstone, claystone and mudstone of the Brunswick Formation. The Brunswick is a heterogeneous unit, and beds of calcareous siltstone, argillaceous limestone and dolostone have also been identified.

The upper portion of the Brunswick Formation is deeply weathered clay and rock (shale) fragments, and it is overlain by a surficial deposit (generally less than 4 ft) of sand, silt, clay and gravel. The Brunswick Formation tends to increase in competency with depth.

The Brunswick Formation in this area is observed to strike N40°E to N50°E and dip gently to the NW about 10 to 15°. The lineament study in this area concluded that most of the fractures in the bedrock are not bedding plane joints, but rather sets of fractures at an acute angle to bedding. The predominant trend of fractures was found to average N60°E; the inclination of these joints is uncertain. However, if this fracture set can be associated with a water saturated fracture system identified by geophysical soundings in the area between Route 206 and Robin Drive (see Section 5.1.1), this fracture set may be nearly vertical. Nevertheless, the geophysical survey also identified some near-horizontal fracture zones, which may be associated with the bedding planes.

Nearly all of the porosity in the Brunswick Formation is fracture porosity. Although the distribution of fractures with depth in the Brunswick Formation is not known, the inventory of existing monitoring and water supply wells in the Montgomery Township/Rocky Hill site (Table 3-1) suggests that water-bearing zones persist to a depth of at least 500 ft. The high yields produced by these wells are further evidence of extensive deep fracture systems. An interpretation of the slug test data suggests that locally, most of the fractures intercepted by an individual well are limited in extent with respect to their ability to transmit water. However, more extensive water-bearing fractures which persist over 1,500 ft or more are evidenced by the results of the pumping test.

6.2 HYDROLOGY

As mentioned above, ground water beneath the site occurs primarily in porous fractures in rocks of the Brunswick Formation, the principal regional aquifer. Shallow and deep monitoring wells were installed within this aquifer in order to investigate conditions in the aquifer, including:

- depth to ground water;
- ground water gradients;
- quality of the ground water;
- aquifer properties;
- degree of connectivity between upper and lower parts of the aquifer;
- potential for vertical flow; and
- flow rates.

Depth to ground water in the shallow wells (screened in the weathered top of bedrock) was found to range from approximately 5 to 54 ft below ground surface. Deeper wells (to depths of 100 to 250 ft) uniformly exhibited lower piezometric heads than the paired shallow well, indicating a potential for downward vertical flow of ground water.

Contours of ground water elevations and piezometric head appear concordant with the topographic contours in the MTHD. That is, the ground water table is a subdued expression of the land surface. Ground water is generally deepest under topographic highs. Ground-water flow in both the shallow and deep aquifers appears to be toward the Millstone River and Beden Brook. The shallow aquifer intersects and discharges to the Millstone River and Beden Brook and to several small streams which are tributaries of the Millstone River and Beden Brook.

Ground water flow (seepage) velocities may be calculated for the area by applying the equation:

$$V = \frac{KI}{n}$$

where V is the seepage velocity, K is the hydraulic conductivity, I is the gradient, and n is the effective porosity. This assumes porous medium equivalent flow, which becomes more appropriate as the ratio of aquifer thickness to lateral extent decreases. WCC considers this assumption to be valid when evaluating flow over a large area.

Using a typical gradient for the piezometric surface of the deep wells of .03 (Section 5.2.1.1) and a maximum hydraulic conductivity of 1.5×10^{-5} ft/sec based on the slug test data (Section 5.2.1.3), the maximum seepage velocity is 142 ft/year. The minimum measured conductivity of 6.4×10^{-7} ft/sec results in a seepage velocity of 6 ft/year. These calculations assume an effective porosity of .10 (Driscoll, 1986). Similar calculations based on shallow well data produce seepage velocities of 123 ft/year and 11 ft/year.

Although the potential for downward vertical flow exists, hydrologic and geochemical evidence suggests that zones of high vertical permeability may be discontinuous and limited in extent. For example, as discussed in Section 5.2.1.2, pumping of the Rocky Hill Municipal Well caused drawdowns in the deep wells, but none of the shallow wells appeared to be affected during the period of pumping. This indicates that the continuity of fractures between the shallow and deep aquifers is limited, at least within the radius of influence, or approximately 1000 to 2000 ft from the pumping well. It also may be that during the pumping test the shallow fractures were so rapidly refilled by lateral recharge that any drawdown in the shallow wells caused by pumping was masked. This effect would be evident if horizontal permeability is considerably greater than vertical permeability. As discussed in Section 5.2.2.2, the ground water from the shallow and deep wells appears to be geochemically fairly distinct with respect to the major dissolved cations. This chemical distinction suggests that complete mixing between the deep and shallow zones of the aquifer is not occurring, at least in the vicinity of wells MW-1, MW-2, MW-11 and MW-14. However, the ground water chemistry (and TCE concentration) appear to be similar between deep and shallow levels of the aquifer at MW-7, suggesting that some vertical communication in the aquifer may be present at least near that location. In addition, the persistence of ground water contamination to depths of 250 ft (the depth of the deepest monitoring wells) indicates that some degree of vertical communication in the aquifer must occur locally.

6.3 CONTAMINATION ASSESSMENT

6.3.1 Contaminant Plume

Summaries of ground water TCE concentration obtained during WCC's Round One and Round Two sampling programs are illustrated in Figures 6-1 and 6-2, respectively. Although other organic contaminants have been detected in monitoring and domestic wells, TCE is used as an indicator parameter in this discussion because it is the most consistently evident contaminant. TCE contamination observed in the 1986 and 1987 sampling rounds extends from Route 518 approximately northward to Sycamore Lane, and from Route 206 eastward to the Millstone River. The maximum TCE contamination was observed in wells MW-7S and MW-7D, and high levels of contamination follow a trend from this well set north-northeast to MW-3S and MW-3D, and thence eastward through the ends of Oxford Circle and Cleveland Circle. In general, TCE concentrations decreased from MW-7 to the south and to the north and east during first round sampling. During second round sampling the highest levels of contamination were detected in MW-4D. Trends of decreasing TCE concentrations were away from MW-4D, towards the north, south and east.

Other frequently occurring organic contaminants encountered during the 1986 sampling round (see Sections 5.2.2.2 and 5.3.2) are found throughout the TCE plume, but they occur more sporadically across the site. For example, 1,1-dichloroethane was detected only in two residential wells on Sycamore Lane and one residential well on Oxford Circle. Tetrachloroethene and trans 1,2-dichloroethene were found in MW-7S and MW-7D (the wells containing the maximum TCE concentration), and also in several other wells to the north and east. In general, the concentration of these two compounds decreases from MW-7S and MW-7D north and east toward the Millstone River. No other chlorinated organic compound exhibited this trend. During second round sampling trans 1,2-dichloroethene exhibited a concentration pattern similar to that of TCE at that time. Also during Round two, tetrachloroethene, in general, followed the same concentration pattern which it had during Round one.

Figure 6-3 delineates the TCE contaminant plume based on mean averages of all available historical and recent data on ground water quality in deep monitoring and water supply wells. The boundaries of the plume were approximated by interpolation between wells. The shaded zones on this figure represent areas of the site where it is probable that ground water of the indicated TCE concentration would be encountered in the deep aquifer at the present time. Note that the nature of fractured-bedrock flow is such that clean wells can exist within the plume.

The distribution of inorganic contaminants within the site area cannot be correlated with the plume of organic compound contamination. The occurrance of high levels of inorganics may be related to piping corossion at individual residences or to faulty well construction (i.e. MW-3D).

6.3.2 Contaminant Migration

Comparing the shape of the contaminant plume (Figure 6-3) and the ground water contours after 3 hours of pumping (Figure 5-5) and without pumping (Figures 5-3 and 5-4), it appears that the shape of the contaminant plume is to some extent consistent with the inferred ground water flow directions. That is, it trends generally northeast. In the MTHD, the part of the plume passing beneath Oxford Circle and Cleveland Circle is approximately parallel to the expected east-northeastward direction of ground water flow. This is consistent with both pumping and non-pumping conditions in the deep and shallow wells in that area. From just south of MW-7 ground-water contours during pumping indicate that flow is toward the RHMW. This suggests that the southern end of the contaminant plume may have been extended to the south through capture by the pumping well. The section of the plume beneath the Montgomery Shopping Center approximately parallels the second-most frequent set of lineaments defined in this study (azimuth 10 to 23 degrees).

The difference in ground water elevations between MW-4 and MW-14 indicates that ground water in the northwestern part of the MTHD would tend to flow to the north or northwest. This area is near the apparent "bend" in the plume. Based on ground water elevations alone, it is unclear why the contaminant plume does not extend farther northward toward Beden Brook. (Note that the northern-most TCE detected was in the Sycamore Lane residence wells.) The absence of contamination to the north may be explained by a number of possibilities:

- The contaminants are more strongly attenuated to the north due to variations in lithology and they are no longer detectable in ground water after the plume passes the Sycamore Lane area.

- Anisotropy in the aquifer is marked, and east-northeast trending fractures parallel to the northeastern limb of the plume preferentially transport the contamination in a narrow pathway toward the Millstone River. The connectivity or density of northward-trending fractures may be limited, as suggested by the lineament study while the east-northeast trending fractures are much more prominent (see Figure 5-2). Thus the pathways for contaminant flow northward toward Beden Brook may be restricted as compared with those towards the east-northeast. The existence of an east-northeast fracture system to facilitate movement in that direction is inferred by the local topography. A sharp bend in topographic contours just north of Cleveland Circle may reflect the presence of a weathered fracture zone. The apices of these bent contours align well with the "core" of the east-northeast limb of the plume. A lineament just north of this area has a similar orientation (see Figure 5-2).

- Because of the likely anisotropy of the aquifer and the lesser permeability in the northwesterly direction, it is possible that the leading edge of the plume to the north may not yet have migrated much beyond Sycamore Lane.

The shape of the plume in the area of the housing development agrees, in general, with earlier investigations. However, in detail, the TCE concentrations in most of the individual wells have fluctuated through time without any apparent pattern. For example, at Block 29002 Lot 33, the TCE concentration has increased from 39 ug/l in 1979 to 340 ug/l in 1986, whereas TCE in the neighboring domestic well at Block 29002 Lot 28 went from 2 ug/l in 1979 to 950 ug/l in 1982 to ND in 1986. (See Appendix B.) There does not appear to be any overall temporal trend with respect to TCE concentration in wells, i.e., there is no evidence that ground water quality in the entire MTHD is significantly improving or deteriorating through time since sampling began in 1979.

These data suggest that although there are perturbations over time in the contaminant plume on the scale of a few hundred feet, the plume overall has appeared to be at a steady state for at least the last 8 years (1979 to 1987). This apparent state may be due to two conditions: (1) the source or sources of contamination have been constant since at least before 1979, or (2) the source or sources of contamination are no longer present but the rate of contaminant migration is so slow that the plume has not yet been appreciably dispersed. The maximum likely ground-water velocity calculated in Section 6.2 is 142 ft/year;

assuming that longitudinal dispersion and retardation are not significant effects (or that they cancel each other) and that only horizontal migration occurs, the maximum distance that a slug of water would have traveled in the past 10 years is about 1500 ft. The minimum possible horizontal distance under similar assumptions is about 60 ft in 10 years. The plume is over 4,000 ft in length. At the maximum transport rate it would have taken 25 years to form a plume this size from a single source. At the minimum rate it would have taken 700 years. Using these rough approximations, it is not possible to rule out either condition 1 or condition 2.

Based on inferred direction of ground water flow and the observed plume of TCE contamination, a region potentially threatened by ground water contamination may be outlined. The shaded region in Figure 6-4 was constructed by extending the plume of Figure 6-3 along the flow lines inferred from Figures 5-3 to 5-6 as far as Beden Brook and the Millstone River. Figure 6-4 is not intended as a prediction of the future extent of the contaminant plume. Although contamination has not been detected in the northern and southeastern parts of this region, there is no known obstacle to ground water flow from the known extent of the plume toward these areas.

Vertical contaminant migration is evidenced by the presence of TCE in deep and shallow wells throughout the extent of the plume. In particular, identical TCE concentrations (650 ug/l) were detected at MW-7D and MW-7S, the point of maximum observed contamination. Because the ground-water elevations suggest that flow from shallow to deep levels occurs at least in transmissive regions of the aquifer, a shallow contaminant source which migrated both downward and laterally is indicated.

Potentially Responsible Parties

The results of this investigation pertinent to each of the potentially responsible parties are discussed below.

Princeton Airport is approximately 3,000 ft from the identified extent of the contaminant plume, and it appears to be upgradient of the area of maximum contamination. Several wells (MW-5D Airport, MW-4S Airport, MW-4D Airport, MW-11, and MW-10) which are between the airport and the plume did not contain detectable amounts of chlorinated organic compounds found in the plume.

Compo Industries lies downgradient of the RHMW and MTHD. Monitoring well MW-13 is between this facility and the RHMW. No chlorinated organic compounds characteristic of the plume were detected in MW-13D or MW-13S. Therefore, it appears that contaminants are not being drawn into RHMW from Compo Industries.

Ingersoll Rand is also outside of the known extent of the plume. MW-1 and the domestic well at Block 23001 Lot 17 are between Ingersoll Rand and the plume, and neither of these wells contained detectable amounts of chlorinated organic compounds. Ingersoll Rand is also downgradient of the inferred extent of the identified plume. On several occassions TCE was detected in the industrial well at this site. TCE was used as a machinery degreaser at this facility and it is possible that Ingersoll Rand caused the contamination of their own well.

Princeton Volkswagen is situated on the upgradient side of the RHMW. Therefore, it is highly likely that ground water beneath this site passes close to and is drawn into the RHMW. Since MW-10 contains no contamination and roughly lies between Princeton Volkswagen and the RHMW it is reasonable to assume that no contamination is originating from this site and reaching the MTHD/RHMW site.

According to the potentiometric surface maps based on both deep and shallow well data water beneath the Texaco Station on the northwest corner of the intersection of Routes 206 and 518 and the Village Shopper shopping complex should flow approximately due north, towards Bedens Brook. The absence of contamination north of the Station (except for below-detection-limit concentrations of TCE in the Village Shopper well) suggests that these are not the sources of contamination in the MTHD. Soil and septic samples from these sites contained no chlorinated hydrocarbons. Because pump test data indicate that during periods of pumping water is not drawn from this area into the RHMW it is unlikely that contamination in the RHMW originated from these sites.

The former site of Thuls Mobil Station lies very close to a divide in ground water flow patterns. That is, ground water beneath this site could move away in several directions ranging from north,to east to southeast. Also, the site lies very close to the northwestern-most area of influence of the RHMW. These factors make it a candidate for a source of contamination. Up to 120 ug/l of TCE was detected in ground water samples collected from this site in 1983. However, it has been stated that solvents were not used at this facility (see Section 3.4.2). No significant contamination was found in soil samples from this site. The Town and Country Animal Hospital is situated between the Thuls site and the RHMW. Two ground-water samples collected from the Animal Hospital in 1979 and 1983 showed no contamination. This suggests that the Thuls site may not be a source of contamination in the RHMW because contamination eminating from Thuls would probably be intercepted by the Animal Hospital during pumping of the RHMW.

As mentioned above, The Town and Country Animal Hospital has never shown contamination in its own well. A soil sample from this site contained no significant contamination. This, combined with the size and nature of this operation, makes it an unlikely source of contamination.

The William Penn Service Station, like the Thuls site, is situated close to a ground water divide. It too has shown the presence of TCE (up to 9 ug/l) during two sampling events. Soil and septic samples from this site revealed no contamination.

The Montgomery Shopping Center is situated close to the upgradient end of the "core" of the plume. A well situated in the center of this property (MW-16) contained no contaminants. A well near the northwest corner of the property (MW-18) contained 2.3 ug/l of TCE. A well near the northeast corner of the property (MW-17) contained 300 ug/l TCE. Septic tank samples taken from two tanks located along the west edge of the property contained contaminants, none of which appear to be related to the chlorinated hydrocarbons found throughout the plume. Soil borings from this site contained no significant contamination. Previously, a septic tank on this site was found to contain high concentrations of Trichloroethane (TCA). This contamination is not thought to be related to the plume because TCA does not typically degrade to TCE.

Wells at both 1377 Route 206 and the former site of Polycell contain or have contained high concentrations of TCE. The contaminant plume moves away from the area of these two sites towards the housing development suggesting that they could be a source of contamination. However, the ground water flow patterns make it impossible for these sites to have caused the contamination which is present in wells MW-17, MW-7, MW-9, and the RHMW. Trichloroethene is not reported to have been a raw material or product at either of these facilities.

Wells located on the Princeton Gamma Tech facility site have containe high concentrations (up to 650 ug/l) of TCE during this study. Soil borings and sep..c tank samples from this study contained no significant contamination.

Results from an ECRA investigation currently underway at this facility support the presence of high levels of TCE in the ground water beneath the facility (Appendix I). Ground water samples obtained during this study contained up to 5900 ug/l of TCE, and 14000 ug/l of 1,2-dichloroethene. A water samples from the septic tank currently in use contained 15 ug/l of TCE. Sludge in a distribution box for a septic system which is no longer in use contained 147 ug/kg of TCE. A soil sample collected from the site, a leach field associated with the former septic system contained 8 ug/kg TCE. TCE levels decrease in all directions away from the property.

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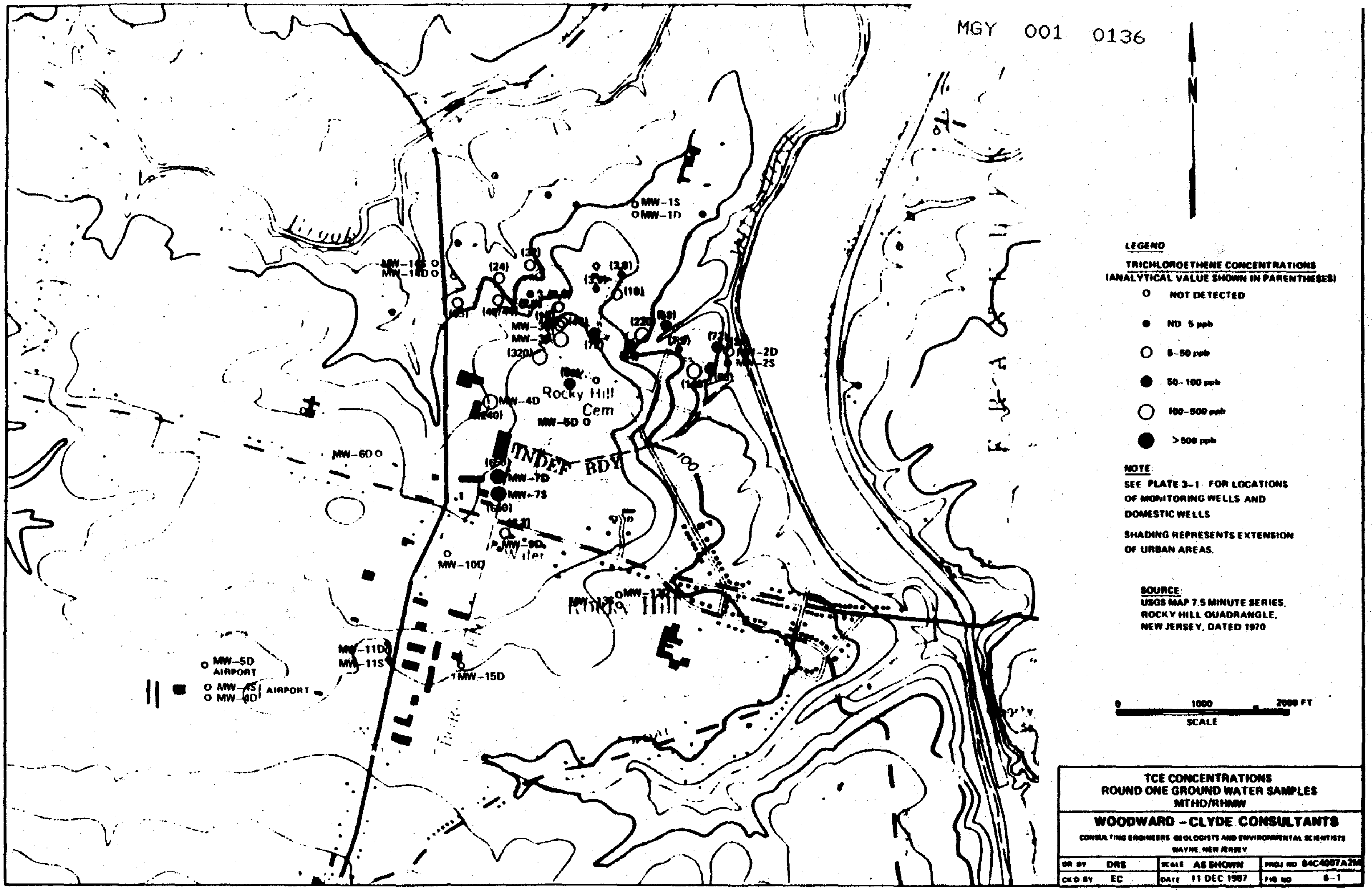
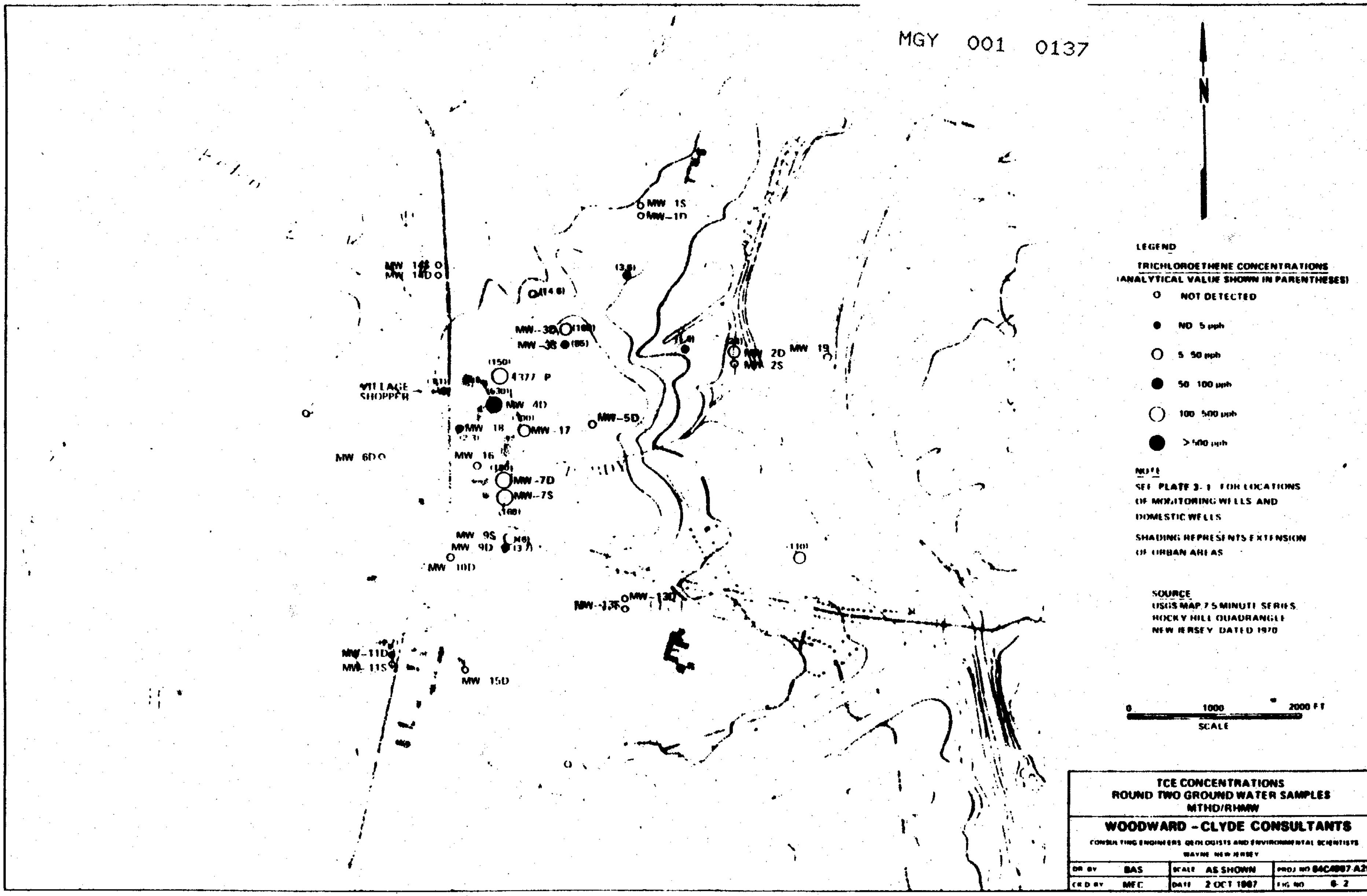
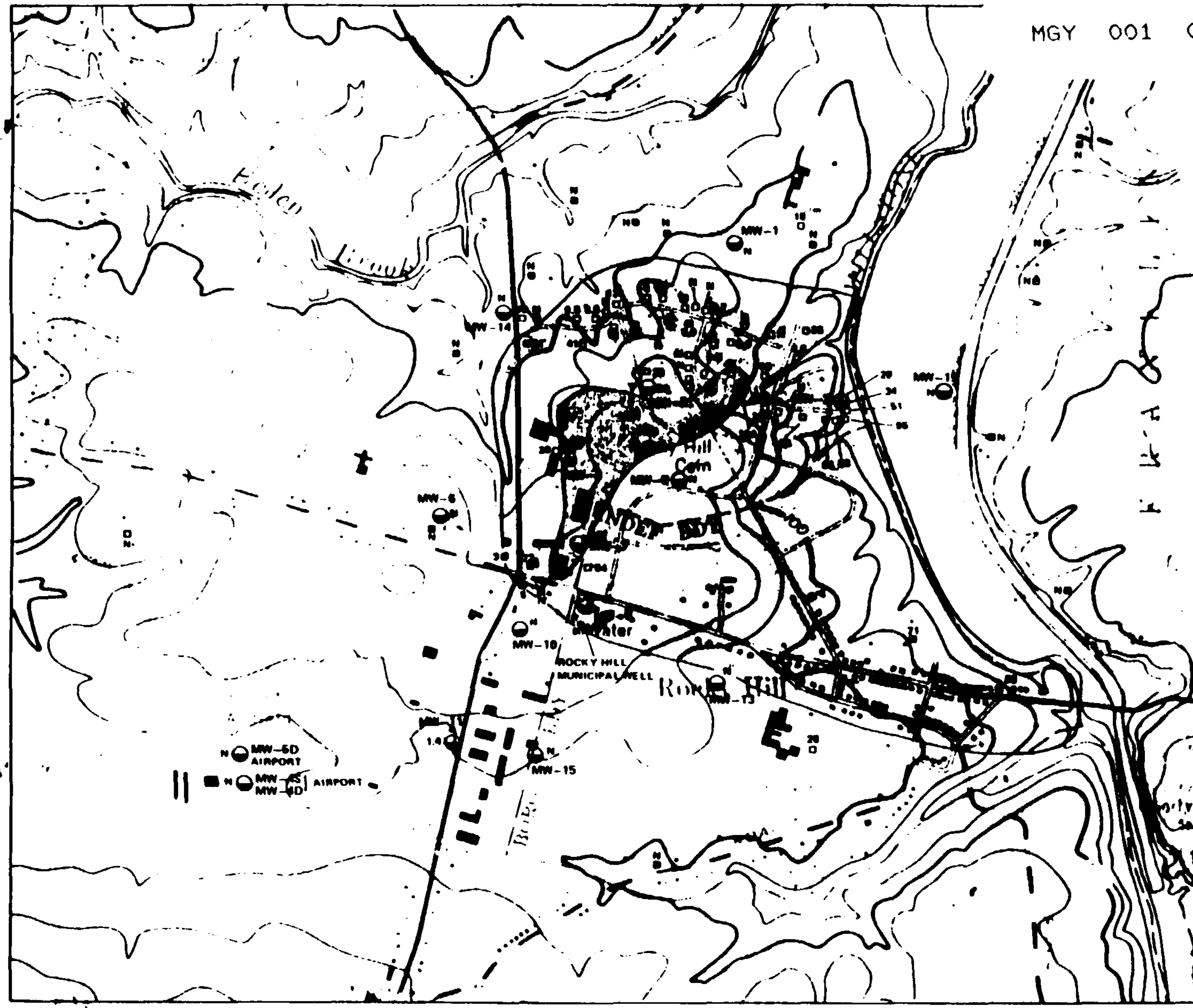
Previous samples of this facilities septic tank contained 8,900 ug/l TCE. A ground water divide is located near or on the Princeton Gamma Tech facility site. The location of this divide may be influenced by pumping activities at the Rocky Hill Municipal Wellfield. For this reason, the direction of ground water flow in the deep bedrock aquifer from the site is expected to vary in accordance with the location of the ground water divide. The site is located at the upgradient end of the "core" of the plume, and is within the radius of influence of pumping of the RHMW. Trichloroethene is a raw material used in production at this facility. The historical use of TCE at this site, its proximity to the RHMW and the southern end of the plume make it a likely source of contaminants.


N
MW-1S
MW-1D
MW-4D
(240)
Rocky Hill
Cem
MW-5D
MW-6D
MW-7D
MW-7S
MW-2D
MW-2S
(24)
(320)
MW-10D
MW-11D
MW-11S
MW-15D
MW-5D
AIRPORT
AIRPORT
LEGEND
TRICHLOROETHENE CONCENTRATIONS
(ANALYTICAL VALUE SHOWN IN PARENTHESES)
NOT DETECTED
ND 5 ppb
5-50 ppb
50-100 ppb
100-500 ppb
>500 ppb
NOTE:
SEE PLATE 3-1 FOR LOCATIONS OF MONITORING WELLS AND DOMESTIC WELLS
SHADING REPRESENTS EXTENSION OF URBAN AREAS.
SOURCE:
USGS MAP 7.5 MINUTE SERIES, ROCKY HILL QUADRANGLE, NEW JERSEY, DATED 1970
0
1000
2000 FT
SCALE
TCE CONCENTRATIONS
ROUND ONE GROUND WATER SAMPLES
MTHD/RHMW
WOODWARD - CLYDE CONSULTANTS
CONSULTING ENGINEERS GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY
DR BY DRS
CKD BY EC
SCALE AS SHOWN
DATE 11 DEC 1987
FIG NO 6-1


N
MW 1S
MW-1D
MW 14S
MW 14D
(14.0)
(3.8)
MW-3D
MW-3S
(86)
(150)
4377 P
VILLAGE SHOPPER
MW 4D
MW-5D
MW 18
MW-17
MW 6D
MW 16
MW-7D
MW-7S
MW 2D
MW 2S
MW 19
MW 9S
MW 9D
MW 10D
MW-13S
MW-13D
MW-11D
MW-11S
MW 15D
LEGEND
TRICHLOROETHENE CONCENTRATIONS
(ANALYTICAL VALUE SHOWN IN PARENTHESES)
NOT DETECTED
ND 5 ppb
5 50 ppb
50 100 ppb
100 500 ppb
> 500 ppb
NOTE
SEE PLATE 3-1 FOR LOCATIONS OF MONITORING WELLS AND DOMESTIC WELLS
SHADING REPRESENTS EXTENSION OF URBAN AREAS
SOURCE
USGS MAP 7.5 MINUTE SERIES
ROCKY HILL QUADRANGLE
NEW JERSEY DATED 1970
0
1000
2000 FT
SCALE
TCE CONCENTRATIONS
ROUND TWO GROUND WATER SAMPLES
MTHD/RHMW
WOODWARD - CLYDE CONSULTANTS
CONSULTING ENGINEERS GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE NEW JERSEY
DR BY BAS
SCALE AS SHOWN
CK'D BY MFC
DATE 2 OCT 1987
FIG NO 6-2

MGY 001 0138



LEGEND

MW-6 MONITORING WELL LOCATION AND NUMBER

AVERAGE TCE CONCENTRATION 1979 - 1987

N NOT DETECTED

3 - 99 ug/l

≥ 100 ug/l

NOTES:

1. TCE CONCENTRATIONS ARE MEAN AVERAGES OF ALL DATA (1979 - 1987) FOR DOMESTIC, COMMERCIAL WATER SUPPLY, AND DEEP MONITORING WELLS.
2. DETECTION LIMITS FOR HISTORICAL ANALYSES VARIED BETWEEN 1 AND 5 UG/L.
3. THE CONCENTRATION FIELDS ARE SHOWN ONLY TO AID IN THE VISUALIZATION OF THE DISTRIBUTION OF TCE ACROSS THE SITE. THE CONCENTRATION FIELDS ARE INTENDED TO ILLUSTRATE AREAS WHERE IT IS PROBABLE THAT GROUND WATER OF THE INDICATED TCE CONCENTRATION RANGE MAY BE ENCOUNTERED AT THE PRESENT TIME.
4. ALTHOUGH THIS PLUME IS BASED ON ALL HISTORICAL DATA, IT IS CONSISTENT WITH THE MOST RECENT (1987) ANALYTICAL DATA.

SOURCE:

USGS MAP 7.5 MINUTE SERIES, ROCKY HILL QUADRANGLE, NEW JERSEY, DATED 1970

0 1000 2000 FT
SCALE

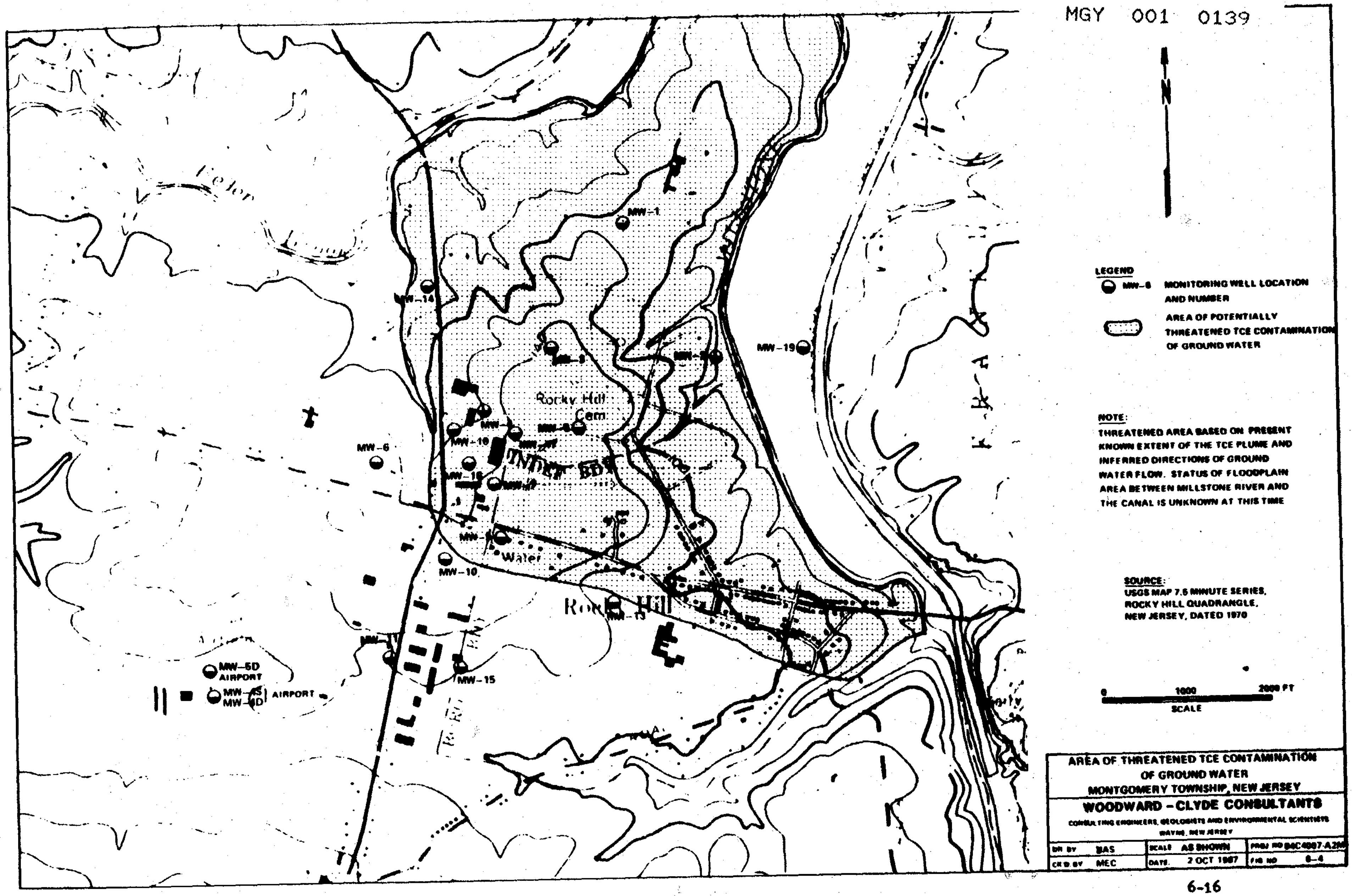
AVERAGE TCE CONCENTRATION IN DEEP MONITORING AND WATER SUPPLY WELLS MONTGOMERY TOWNSHIP, NEW JERSEY

WOODWARD - CLYDE CONSULTANTS

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR BY BAS	SCALE AS SHOWN	PROJ NO 86C4907-A2
CH'D BY MEC	DATE 11 DEC 1987	FIG NO 6-3

MGY 001 0139



N
MW-1
MW-14
MW-19
Rocky Hill Cem
MW-6
MW-10
MW-15
MW-5D
AIRPORT
AIRPORT
Water
Rocky Hill
LEGEND
MW-6 MONITORING WELL LOCATION AND NUMBER
AREA OF POTENTIALLY THREATENED TCE CONTAMINATION OF GROUND WATER
NOTE:
THREATENED AREA BASED ON PRESENT KNOWN EXTENT OF THE TCE PLUME AND INFERRED DIRECTIONS OF GROUND WATER FLOW. STATUS OF FLOODPLAIN AREA BETWEEN MILLSTONE RIVER AND THE CANAL IS UNKNOWN AT THIS TIME
SOURCE:
USGS MAP 7.5 MINUTE SERIES, ROCKY HILL QUADRANGLE, NEW JERSEY, DATED 1970
0
1000
SCALE
AREA OF THREATENED TCE CONTAMINATION
OF GROUND WATER
MONTGOMERY TOWNSHIP, NEW JERSEY
WOODWARD - CLYDE CONSULTANTS
DR BY BAS
CK'D BY MEC
SCALE AS SHOWN
DATE 2 OCT 1987

SECTION SEVEN
CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

Conclusions drawn from this remedial investigation are summarized below.

1. The site is underlain by a fractured bedrock aquifer which consists of an upper unconfined section and a lower semi-confined section with varying degrees of downward vertical communication existing between the two.

2. Ground-water flow is toward the NE in the eastern part of the MTHD and to the NW in the northwestern part of the MTHD with shallow water discharging directly into surface water bodies.

3. There is no definable vertical distribution pattern of contaminants and there is no correlation between levels of organic and inorganic contaminants. The pesticide Chlordane occured in only one well and is not considered to be a plume related contaminant.

4. The areal extent of known contamination is bounded roughly by:

    - o the Millstone River on the east;
    - o Montgomery Avenue on the north;
    - o Route 206 on the West; and
    - o Route 518 on the South.

5. During this study TCE has been detected in the area defined above, ranging from detection limit (5 ug/l) up to 650 ug/l. Other chlorinated hydrocarbons have also been observed.

6. Based on calculated ground-water velocities it is not possible to determine whether the source of sources of contamination is/are continuing to emit contaminants or whether the source or sources is/are no longer present.

7. Based on the present distribution of contaminants, historical data, ground-water flow patterns and the assumption that conditions now are not appreciably different than in the past, several PRPs are not likely sources of contaminants at the MTHD/RHMW site: Ingersoll Rand, Compo Industries, Princeton Airport, Princeton Volkswagen, Village Shopper, Thuls Mobil, Texaco, William Penn, Town and Country Animal Hospital. The former site of Compo Industries may contribute to contamination in wells downgradient of the site, but not to the MTHD or RHMW. The former site of Polycell, Montgomery Shopping Center and 1377 Route 206 are potential sources of contamination at MTHD but not at RHMW although their contributions cannot be currently distinguished from upgradient conditions. The site of the Princeton Gamma Tech facility has been shown by this study and an ECRA investigation to contain high levels of TCE in ground water, beneath the site. Concentrations decrease in all directions away from the facility. Furthermore, the facilities location is coincident with the upgradient end of the core of the contaminant plume. These factors indicate that the Princeton Gamma Tech site is a potential source of contamination in both RHMW and MTHD.

7.0 RECOMMENDATIONS

WCC does not recommend that additional field work be undertaken at this time. This recommendation is made in accordance with our understanding of this project as follows:

1. the scope of the study presented herein was to obtain sufficient information to permit appropriate remedial activities for the site to be developed; and

2. a study is currently being performed at Princeton Gamma Tech and the results of this study will be made available during site remediation.

7.3 LIMITATIONS

It is recognized that WCC's work is in accordance with our understanding of professional practice and environmental standards existing at the time the work was performed. Professional judgments presented herein are based on our evaluation of technical information gathered and on our understanding of site conditions and site history. Our analyses, interpretations and judgments rendered are consistent with professional standards of care and skill ordinarily exercised by the consulting community and reflect the degree of conservatism WCC deems proper for this project at this time. Methods are constantly changing and it is recognized that standards may subsequently change because of improvements in the state of the practice.

The information used for this work is presented in this report and includes resistivity surveys, boring logs, water level elevations, and water and soil quality analyses. Boring logs reflect subsurface conditions for the indicated locations and dates. Water and soil quality samples represent only a small portion of the pertinent subsurface conditions in the area, both in volume and through time. The interpretations made in this report are based on the assumption that subsurface conditions do not deviate appreciably from those found during our field investigations.

We have assumed that the Brunswick Formation acts as a porous medium equivalent and meets the classical definitions of unconfined and semi-confined aquifers. The Brunswick is an aquifer that is composed of numerous separate interconnection. While it may not appear to meet the conditions for aquifer analysis, evaluation of cores, field observation of water levels and examination of the shape of curves from the pumping test imply that the aquifer zones approximate a porous medium equivalent. As the ratio of aquifer thickness to areal extent becomes smaller, and horizontal flow predominates over vertical flow, the system comes closer to meeting the porous medium limitations. Thus, for the site as a whole, analytical methods based on porous medium flow can be appropriate.

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